ATARNotes

Biology 3/4

Unit 3 Head Start

January Lecture Series

Presented by:

Josh Hamilton

Welcome!

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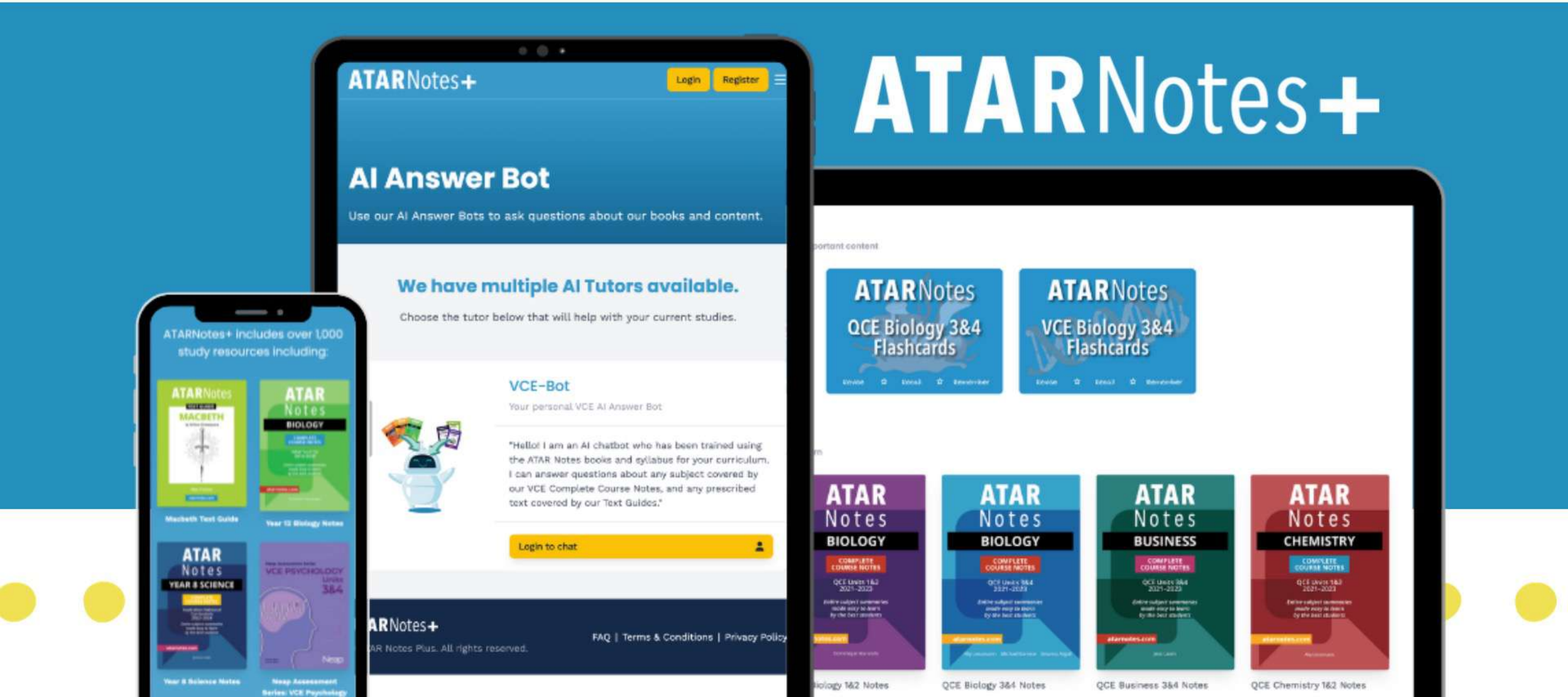


Welcome!!

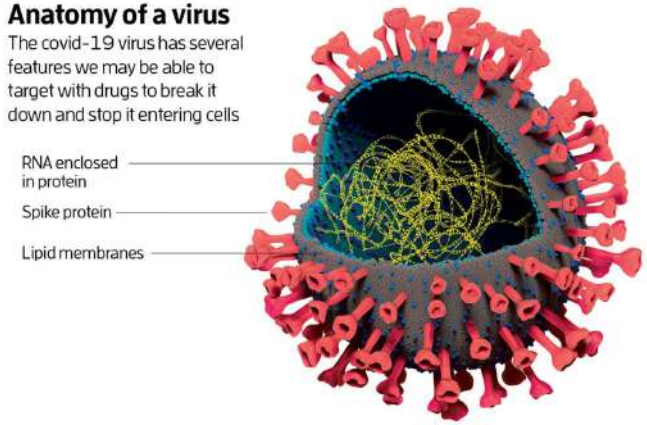
Topics to be covered

- Welcome to the Biology 3/4 head start lecture for 2024 !
- Third year of this study design (the longest of all 3/4's)

House keeping:

- Please feel free to utilise the chat to ask any questions
- The slides should be able to be accessed below
- This recording will be available after the premiere

New Bio 3/4 Study Design:

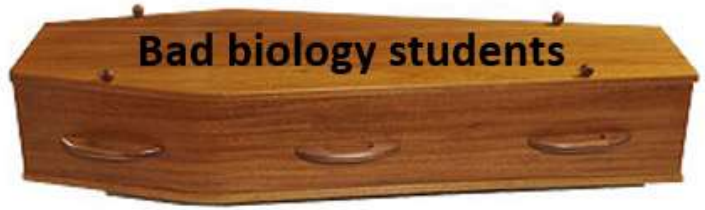


Who am I?

Quick Tips for Success

- Print off the study design and read it
- Get ahead on the course content!
- Practice questions, practice questions, practice questions!
- Learn from your mistakes and focus on your weaknesses
- Ask questions – make sure to ask for help if you need it!
- Focus on your wellbeing too!

- Take breaks, leave time for things you enjoy!



Biology students who attend ATAR Notes biology 3/4 revision lecture

ATARNotes

Area of Study 1

What is the role of nucleic acids and proteins in maintaining life?

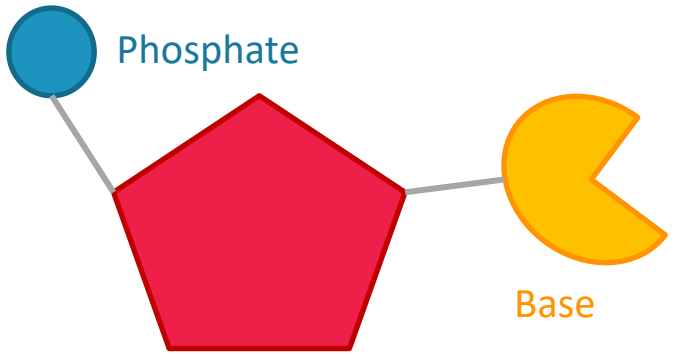
ATARNotes

1. The relationship between nucleic acids and proteins.

Protein Basics

Nucleic Acid

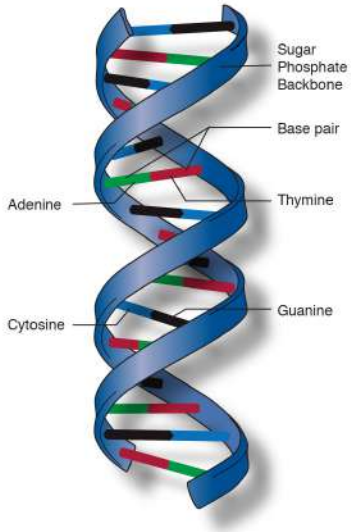
Monomer
Nucleotides



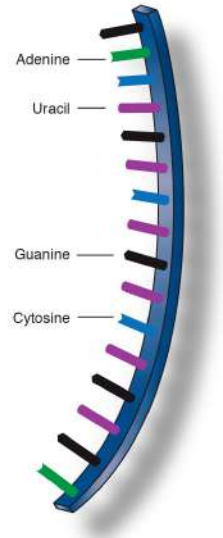
DNA: Deoxyribose

RNA: Ribose

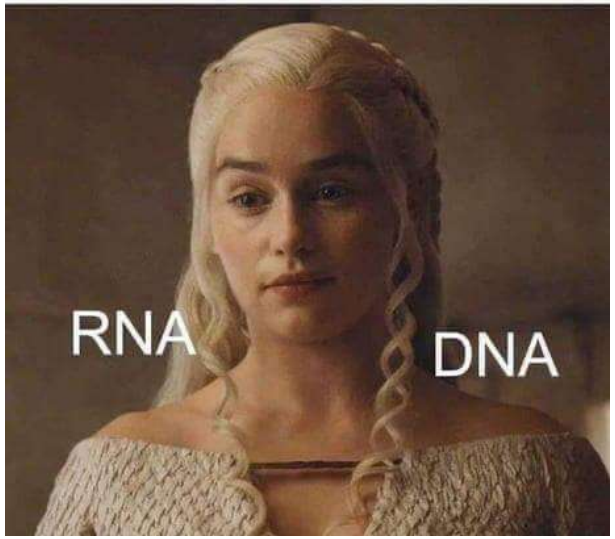
Polymer
Nucleic Acid



Deoxyribonucleic acid (DNA)



Ribonucleic acid (RNA)



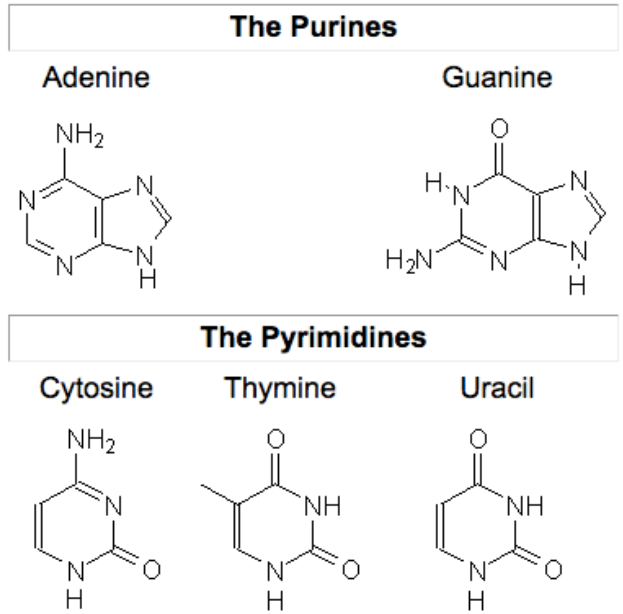
- A nucleotide is made up of:
  - A phosphate molecule
  - A sugar component (deoxyribose for DNA, ribose for RNA)
  - Nitrogenous base (Adenine, Guanine, Thymine, Cytosine, *Uracil*)

- nucleic acids as information molecules that encode instructions for the synthesis of proteins: the structure of DNA, the three main forms of RNA (mRNA, rRNA and tRNA) and a comparison of their respective nucleotides

- Polymer's form via **condensation polymerisation** reactions, a loss of one water molecule each time

- The base pairs bond via *hydrogen bonds*
  - C ≡ G
  - A = T (or U as a part of protein synthesis)
  - Pyrimidines: C, T and U
  - Purines: G and A

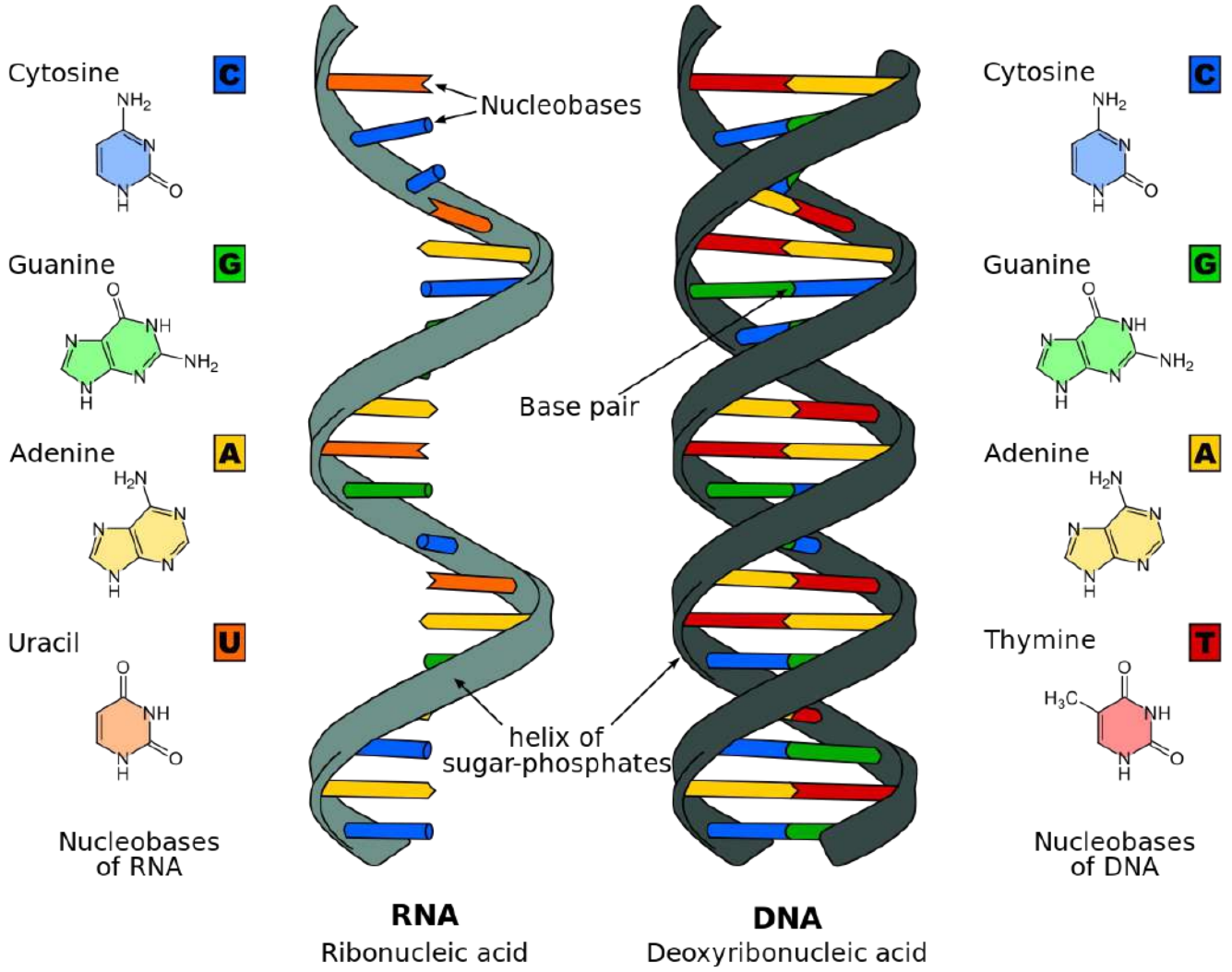
- DNA is anti-parallel:
  - one strand runs 3' to 5', the other runs 5' to 3'



Protein Basics

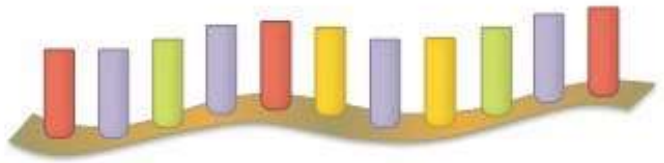
DNA vs RNA

DNA	RNA
Double Stranded	Single Stranded
Contains Thymine	Contains Uracil
Contains a deoxyribose sugar	Contains a ribose sugar
Contains the genetic code and read a part of protein synthesis	Various versions that play various roles as a part of protein synthesis

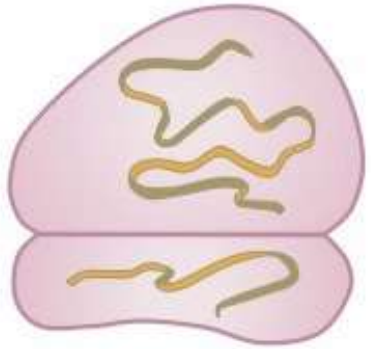


RNA Types

- *mRNA:* carries the code for the production of a protein from the DNA in the nucleus to a ribosome
- *rRNA:* structural component of ribosomes
- *tRNA:* carry amino acids to the ribosome



Messenger RNA (mRNA)



Ribosomal RNA (rRNA)

Transfer RNA (tRNA)

- *Gene:* particular sequence of bases of DNA coding for a specific polypeptide chain
  - Inherited from parent to offspring
  - "locus" = fixed position on a chromosome where a specific gene is located
- *Gene expression:* the transcription and translation of a gene
  - The process in which the genetic material (DNA) is converted into a functional 3D protein
- *Degenerate:* More than one triplet can code for the exact same amino acid molecule; therefore, we refer to DNA as **degenerate**

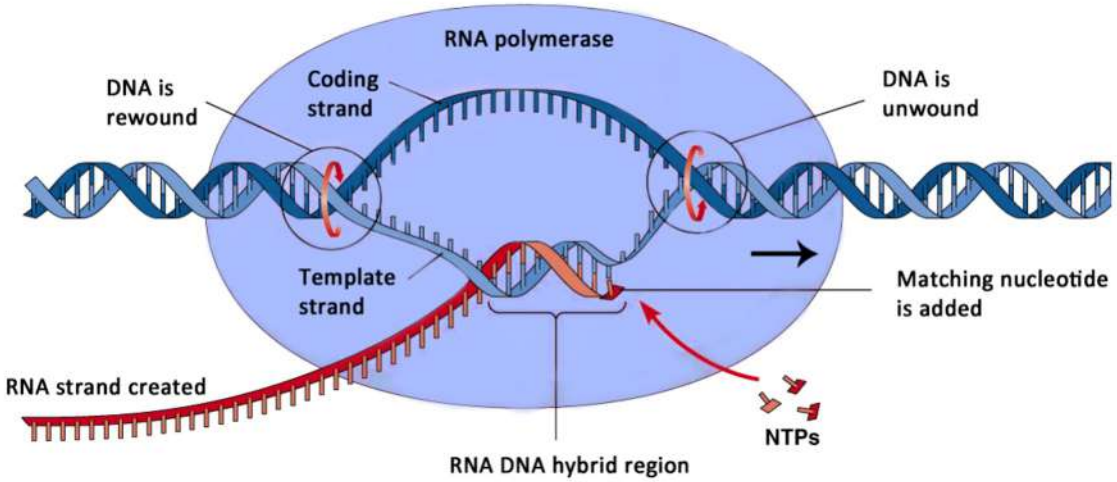
Transcription → Post Transcriptional Modification → Translation → Folding

- the genetic code as a universal triplet code that is degenerate and the steps in gene expression, including transcription, RNA processing in eukaryotic cells and translation by ribosomes
- the structure of genes: exons, introns and promoter and operator regions

Transcription

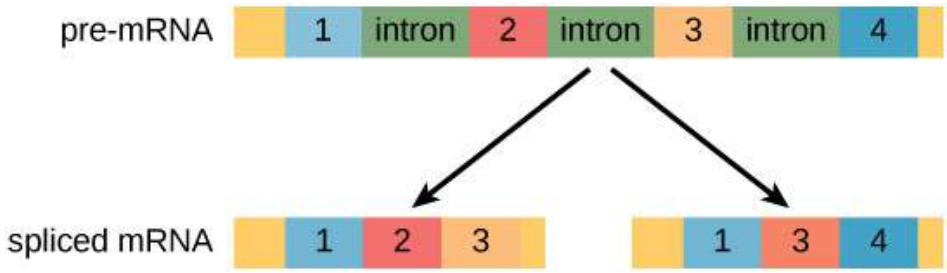
The process of producing mRNA from a DNA template which occurs in the nucleus:

1. An *RNA polymerase* (an enzyme) binds to the **promoter region** of the gene to be transcribed on the *template strand* of DNA
2. The RNA polymerase molecule unwinds the DNA and moves along the template strand 'reading' it in a *3' to 5' direction* whilst synthesising RNA by joining ribonucleotides in the *5' to 3' direction* (remember strands are anti-parallel)
3. When RNA polymerase reaches the end of the gene (termination sequence), the pre-mRNA molecule will be released as a *complementary strand* to the template strand and has the same sequence as the coding strand (except that T is replaced with U)



Post Transcriptional Modification

- Eukaryotic cells undergo three important types of post transcriptional modification within the nucleus
  1. *Introns are removed* and exons are spliced (joined) together
     - Introns are non-coding regions
     - Exons are coding regions (remember exons are expressed)
     - This means that 'mature' mRNA is shorter than pre-mRNA
  2. A *methyl guanosine cap* is added to the 5' end of the RNA molecule
  3. A *poly-A-tail* is added to the 3' end of the RNA molecule
- Once these modifications have taken place, the RNA molecule is mature mRNA and will leave the nucleus and move to a ribosome
- May be referred to as 'exon splicing'

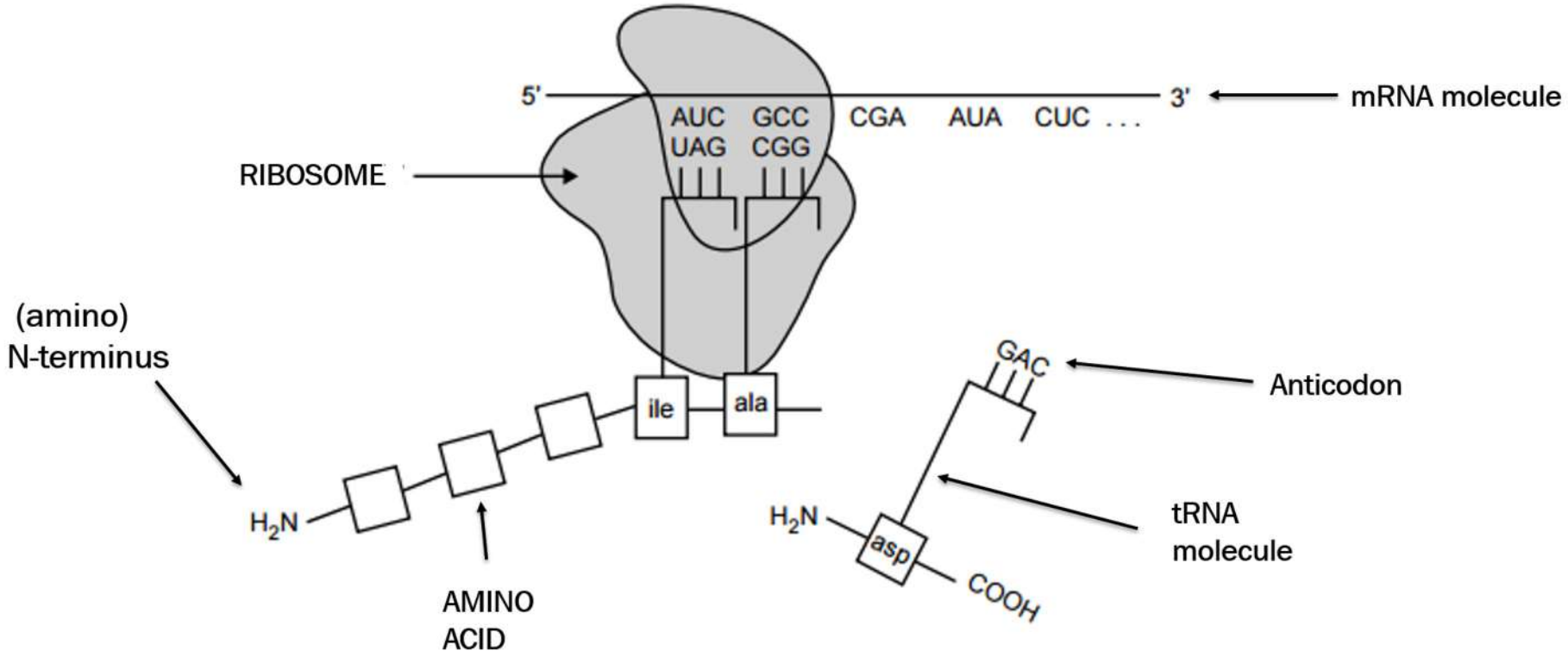


Translation

Now we move to the cytoplasm:

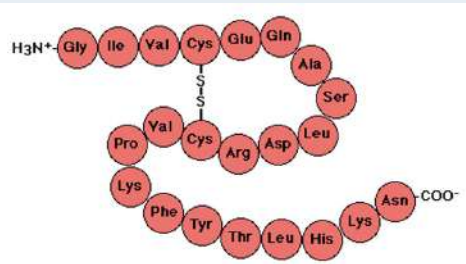
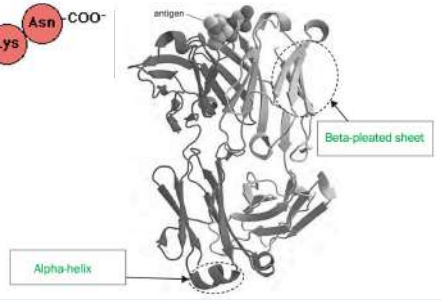
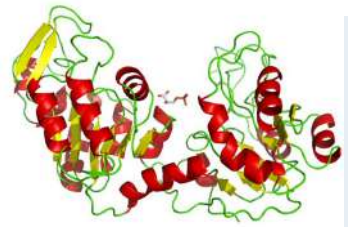
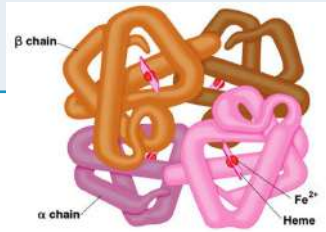
1. Once it leaves the nucleus, the mRNA strand migrates to a *ribosome* and will enter the ribosome at the 5' end
2. The *start codon*, AUG, instructs for translation to begin, directing for the amino acid methionine to start the polypeptide chain
3. Each successive codon in the mRNA will pair up with the *anticodon* of a *tRNA* molecule carrying a *specific amino acid* within the ribosome
4. The process continues with more codons and anticodons pairing, resulting in the amino acids being carried by the tRNA molecules being added to the growing polypeptide chain via peptide bonding (**condensation polymerisation**)
5. Once a *stop codon* is reached, translation will cease, and the polypeptide chain will be released

Protein Basics



Protein Basics

Protein Folding

Level of Folding	Description	Bonds	Diagram
Primary	The specific amino acid sequence of the protein.	Peptide Bonds	
Secondary	Localised coiling (alpha helices) and pleating (beta pleated sheets)	Hydrogen Bonds	
Tertiary	The overall 3D structure of the protein that gives a specific function	Disulphide Bonds Ionic Interactions	
Quaternary	Optional: multiple chains bind together	Not necessary to know	

- amino acids as the monomers of a polypeptide chain and the resultant hierarchical levels of structure that give rise to a functional protein

Protein Basics

Proteome

- Genome: Number of genes in the human body
- Proteome: the totality of proteins expressed within a cell, tissue or organism at a certain time
  - Proteome > Genome
  - Why?

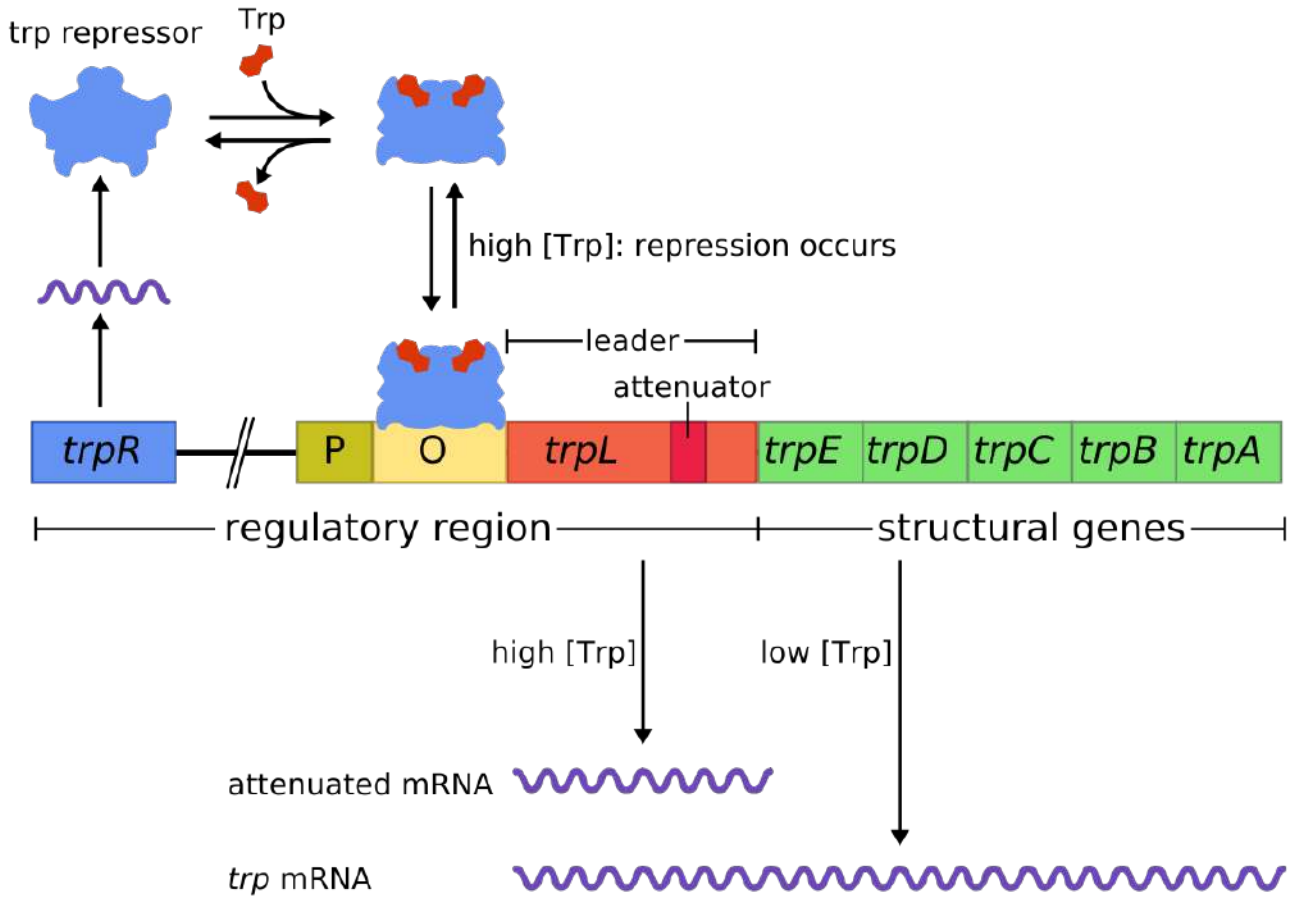
- Types of Proteins →

Type	Example
Structural	Keratin, collagen
Hormones (regulatory)	Insulin
Enzymes	ATP synthase
Transport	Chaperone proteins, protein channels
Contractile	Actin and myosin
Immunological	Antibodies (immunoglobulins), complement proteins
Receptors	Cell receptors for insulin

- proteins as a diverse group of molecules that collectively make an organism's proteome, including enzymes as catalysts in biochemical pathways

Prokaryotic Gene Regulation (Operons)

- Operon: a segment of DNA containing a group of genes that are transcribed together
  - Separate from the promoter (where RNA polymerase binds)
  - Does not exist in Eukaryotes



- the basic elements of gene regulation: prokaryotic *trp* operon as a simplified example of a regulatory process

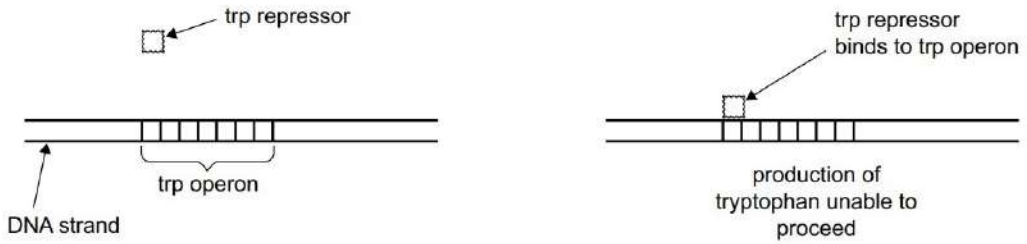
Protein Basics

VCAA QUESTION

Use the following information to answer Questions 27 and 28.

Tryptophan is an amino acid that is produced by many bacteria. Genes that code for the production of tryptophan are found on bacterial DNA and together are called the trp operon.

In the process of gene regulation, a repressor protein (trp repressor) binds to the trp operon. When such binding occurs, the process of tryptophan production stops. This is illustrated in the diagram below.



Question 27

When the trp repressor binds to the trp operon, which one of the following enzymes would be blocked from functioning normally?

A. RNA polymerase
B. DNA polymerase
C. endonuclease
D. DNA ligase

Question 28

Which one of the following factors would increase the concentration of the trp repressor in bacterial cells?

A. low concentration of tryptophan
B. high concentration of tryptophan
C. high concentration of DNA ligase
D. low concentration of DNA polymerase

Protein Basics

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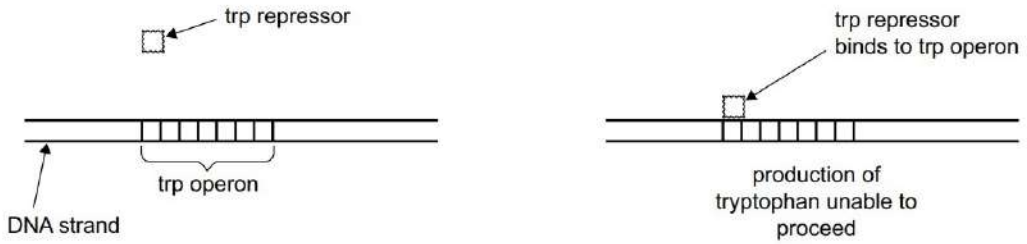

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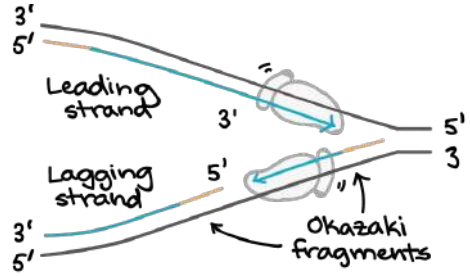
B. high concentration of tryptophan
C. high concentration of DNA ligase
D. low concentration of DNA polymerase

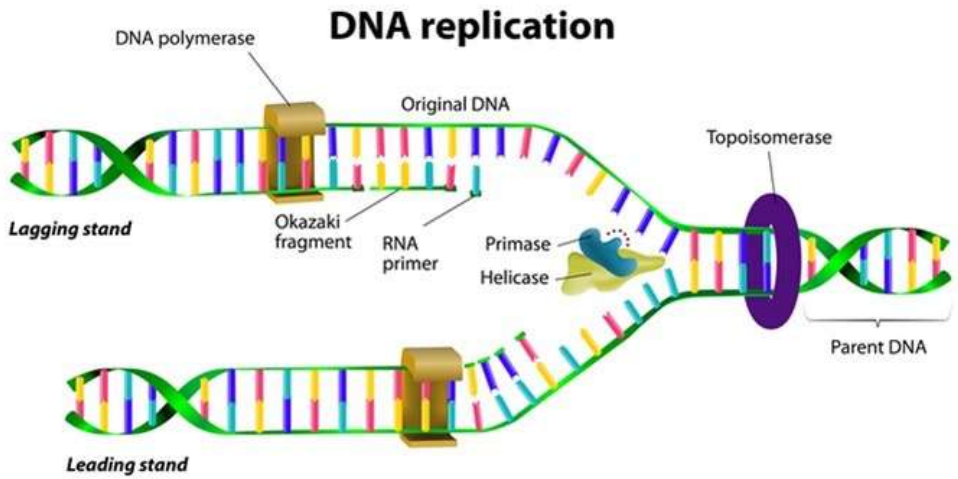
ATARNotes

2. DNA manipulation techniques and applications.

Roles of Enzymes in DNA Synthesis

- Helicase: splits the original DNA strand
- DNA polymerase: reads the original parent DNA strand and forms a new strand with complimentary base pairs
- DNA ligase: smooths and bonds togethers the Okazaki fragments by joining the backbone of DNA
- Endonuclease: cleave the DNA backbone, splitting apart segments of DNA at specific sites





- the use of enzymes to manipulate DNA, including polymerase to synthesise DNA, ligase to join DNA and endonucleases to cut DNA

Endonucleases

- Endonucleases are also referred to as restriction enzymes
- Endonucleases cut DNA at certain *recognition sequences* that are specific to that particular enzyme by breaking the covalent bonds between nucleotides
- Can form either:
  - Sticky Ends →
  - Blunt Ends →

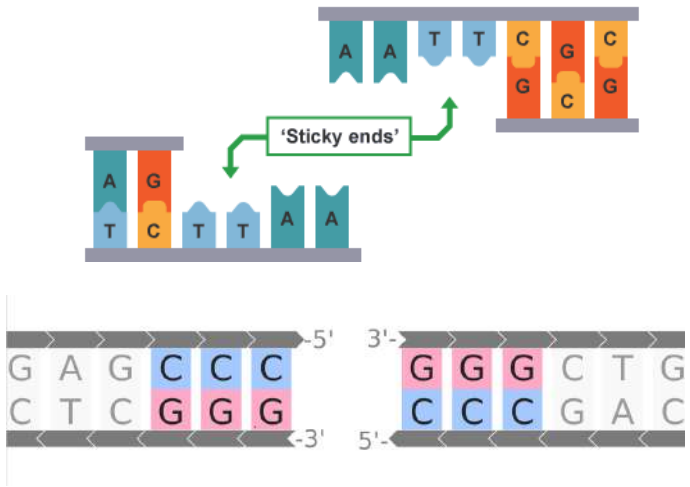


TABLE 2. Some restriction enzymes, their origin and recognition sites

Enzyme	Organism	Recognition sequence (one strand mentioned)
EcoRI	*Escherichia coli* Ry13	5′G↓AATTC3′
BamHI	*Bacillus amyloliquefaciens*	5′G↓GATCC3′
BglII	*Bacillus globigii*	5′A↓GATCT3′
HindIII	*Haemophilus influezae* R_d	5′A↓AGCTT3′
HinfI	*Haemophilus influezae* R_f	5′G↓ANTC3′
Sau3A	*Staphylococcus aureus*	5′↓GATC3′
AluI	*Arthobacter luteus*	5′AG↓CT3′
HaeIII	*Haemophilus aegyptius*	5′GG↓CC3′
TaqI	*Thermus aquaticus*	5′T↓CGA3′
NotI	*Nocardia otitidis-caviarum*	5′GC↓GGCCGC3′
HpaII	*Haemophylus parainfluenzae*	5′C↓CGG3′
PstI	*Providentia stuartii*	5′CTGCAG3′
SmaI	*Serratia marcescens*	5′CCC↓GGG3′
XmaI	*Xanthomonas malvacearum*	5′C↓CCGGG3′

DNA Manipulation

VCAA QUESTION

Genetic engineers use restriction enzymes to cut DNA into smaller lengths. The recognition sequences of several restriction enzymes are shown in the table below. The symbol * denotes the restriction site (position of the cut).

Restriction enzyme	Recognition sequence (read in 5' to 3' direction)
EcoRI	G* A A T T C C T T A A *G
HindIII	A* A G C T T T T C G A *A
AluI	A G* C T T C* G A
HaeIII	G G* C C C C* G G

Question 29

Consider a length of double-stranded DNA with the sequence

5' T T A A G G A A T T C A A 3'
3' A A T T C C T T A A G T T 5'

Adding EcoRI to a solution containing one copy of this double-stranded DNA produces

A. two fragments of double-stranded DNA, each with a sticky end.
B. four fragments of single-stranded DNA, each with a sticky end.
C. two fragments of double-stranded DNA, each with blunt ends.
D. four fragments of single-stranded DNA, each with blunt ends.

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AluI	A G* C T T C* G A
HaeIII	G G* C C C C* G G

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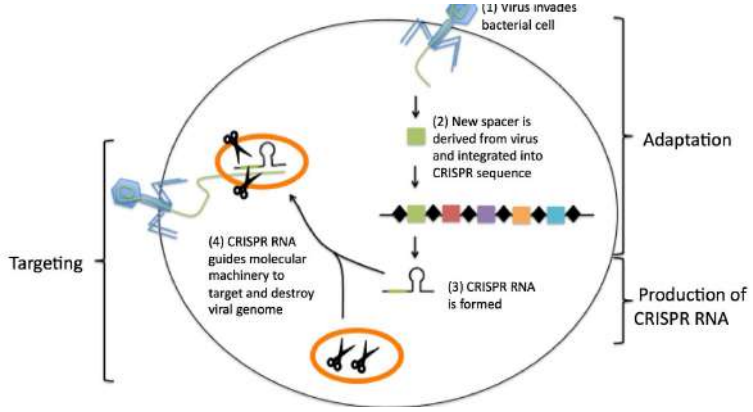
D. four fragments of single-stranded DNA, each with blunt ends.

CRISPR: Clustered Regularly Interspaced Short Palindromic Repeats

Cas9: just a specific endonuclease

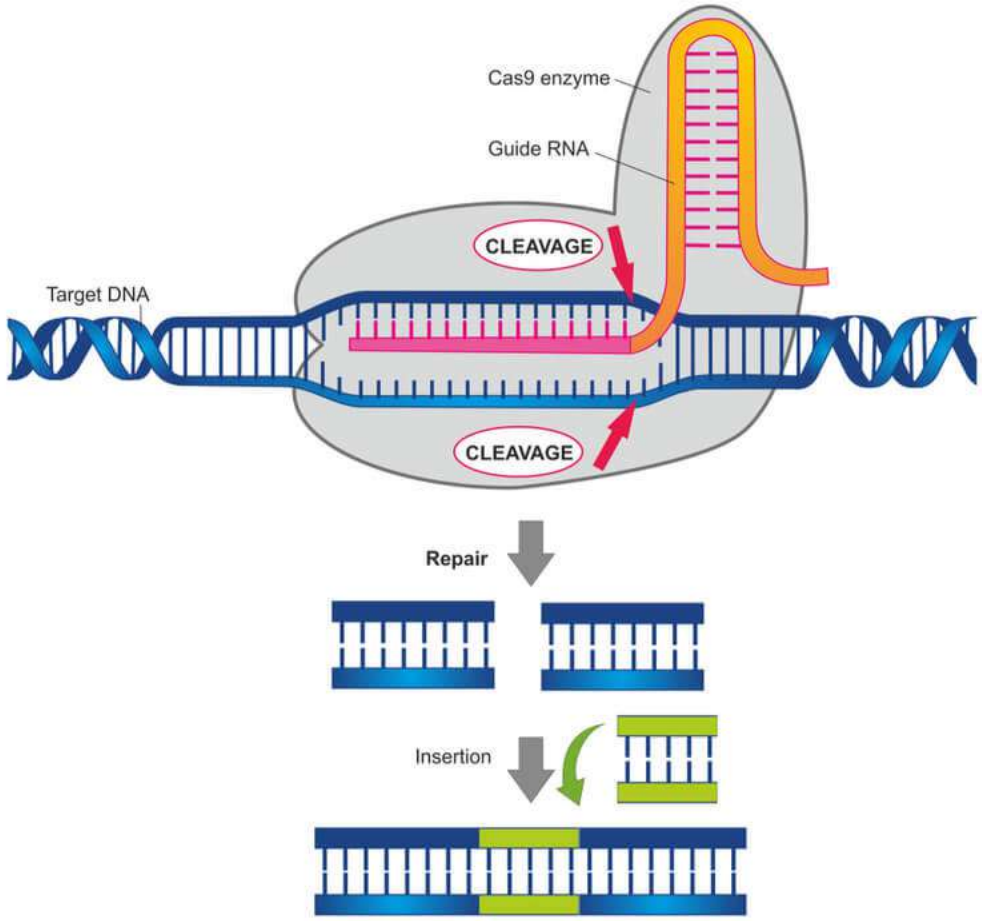
- Essentially for this we need to understand how CRISPR works naturally:
  1. In a natural setting, a bacteria is attacked by a virus where the virus inserts its RNA / DNA
  2. The bacteria takes the nucleic acid and stores it in its own genome
  3. When the virus attacks again, the sequence is transcribed and merged with an endonuclease called (conveniently) Cas9
  4. Due to the transcribed strand being complementary to the viral genetic material, the Cas9 can easily detect and destroy the virus



- the function of CRISPR-Cas9 in bacteria and the application of this function in editing an organism's genome

DNA Manipulation

CRISPR-Cas9



DNA Manipulation

DNA Profiling

Two steps:

1. PCR
2. Gel Electrophoresis

But we all know what our fav PCR test is…

- amplification of DNA using polymerase chain reaction and the use of gel electrophoresis in sorting DNA fragments, including the interpretation of gel runs for DNA profiling

- PCR is a molecular technique whereby DNA is amplified (copied)
  - This is essential if we need to have large quantities of DNA in order to examine it properly but only have a small sample to start with

Ingredients:

- DNA primers: short single stranded DNA segments that are complementary to part of the section of DNA that we want to copy.
- DNA nucleotides: enable us to synthesise new DNA strands
- Taq polymerase: DNA polymerase from the bacteria Thermus aquaticus
- The DNA sample

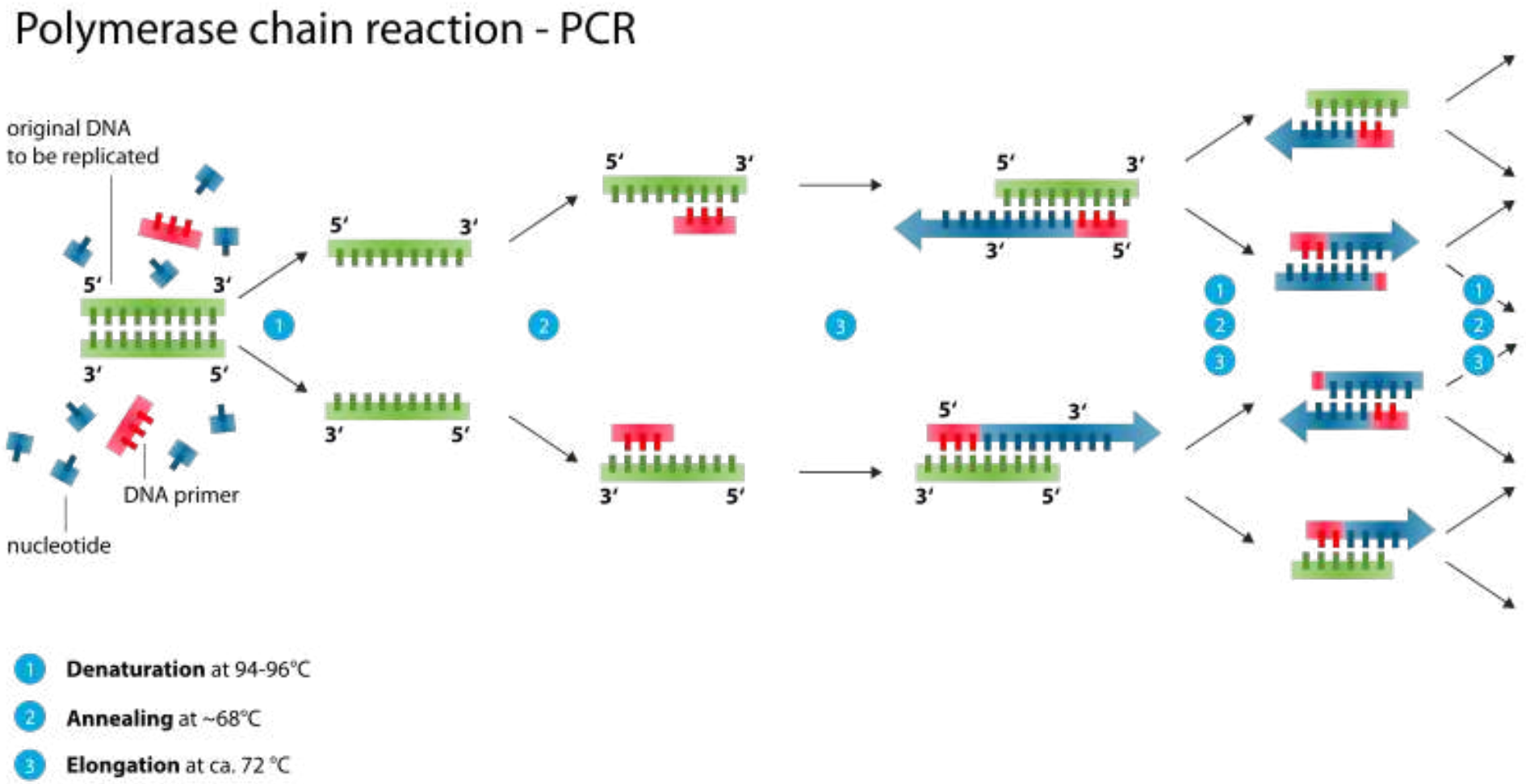
DNA Manipulation

1. PCR

STEP	WHAT IS HAPPENING?
1. The PCR mix containing the DNA sample is heated to *95°C*	**Denaturation:** The heat energy breaks the hydrogen bonds between the strands of DNA causing them to dissociate and become ***single stranded***
2. The sample is then cooled to *55°C*	**Annealing:** The primers are now able to anneal to the single stranded DNA
3. The sample is heated back up to *72°C*	**Elongation:** This temperature allows the ***Taq polymerase to synthesise new DNA strands*** utilising the primers
4. This process is repeated *many* times	Creates larger quantities of DNA

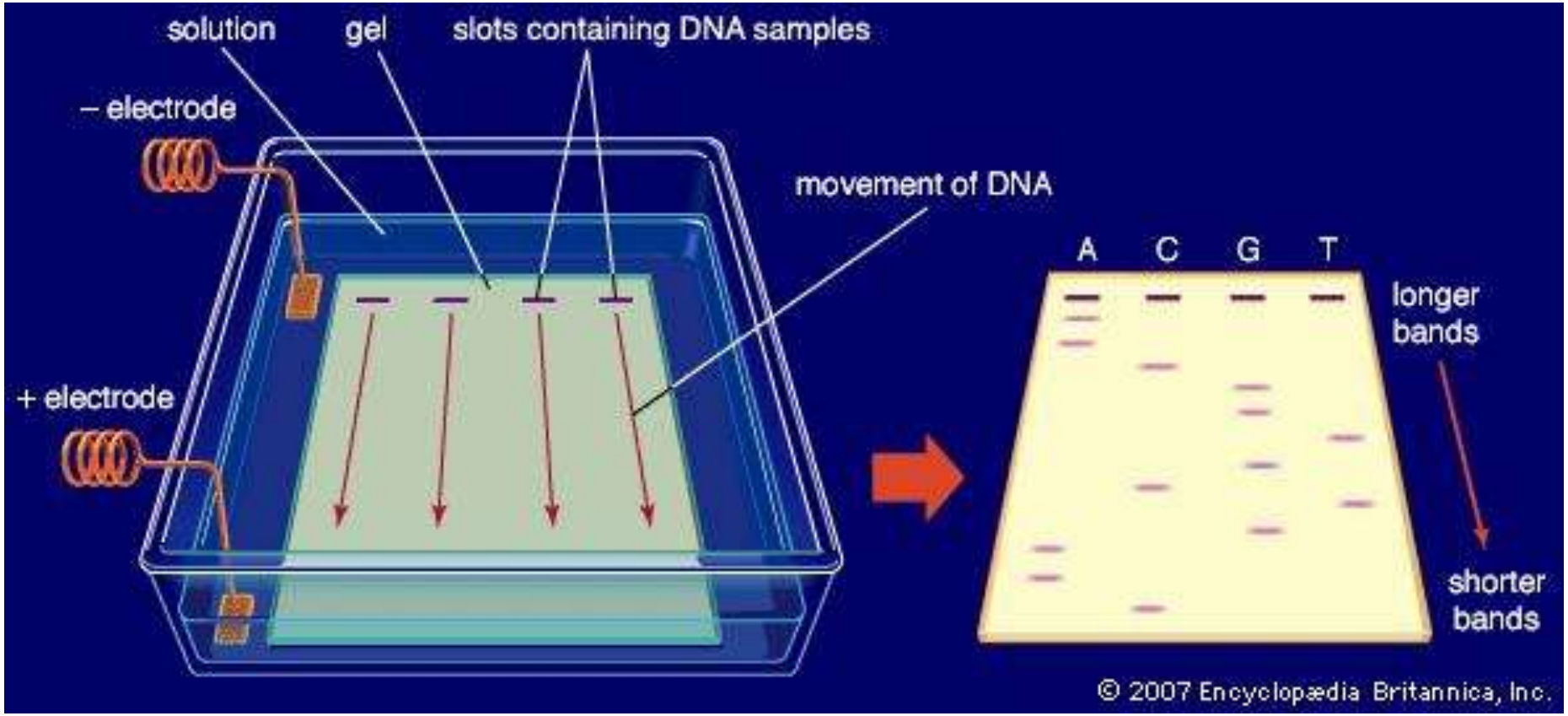
DNA Manipulation

1. PCR



DNA Manipulation

2. Gel Electrophoresis



Type I Diabetes

But first, a little aside…

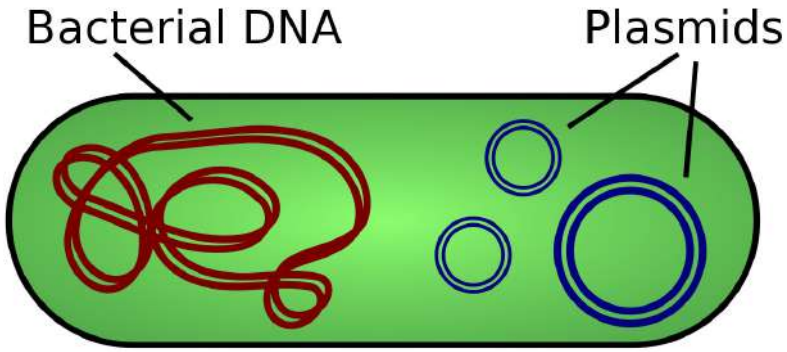
- Type I diabetes is an autoimmune condition that presents mostly in young adolescents where the body attacks the beta cells of pancreas
- These cells produce insulin and so once destroyed, no insulin is produced
  - 0 insulin = eventual death
- Until the 1920's, T1DM was a death sentence but once insulin was discovered, we begun to harvest it from pigs and other farm animals
- This was ok, but most died from complications of foreign insulin
- In 1978, we discovered recombinant plasmid insulin…

Plasmids

So, what is a plasmid??

- Plasmids are non-chromosomal (extra) double stranded DNA found in certain organisms (bacteria specifically)
- Importantly, *bacteria can take up plasmids from the environment and can transfer them through the process of* ***conjugation***

- Other characteristics to note:
  - Plasmids can be cut using restriction enzymes
  - Genes can be inserted into plasmids
  - Plasmids are self replicating



- the use of recombinant plasmids as vectors to transform bacterial cells as demonstrated by the production of human insulin

Recombinant Plasmid Production

And a recombinant plasmid is a plasmid that has been artificially manipulated by us

Process:

1. Cut vector plasmids (often from E. coli) with a specific restriction enzyme
2. Cut the gene of interest using the *same* restriction enzyme (gene of interest and plasmid will therefore have complementary sticky ends)
3. Combine the plasmids and gene of interest together and add *ligase* so that the gene will become incorporated into the plasmid
   - we now describe the plasmids as recombinant
4. A gene for *antibiotic resistance* is usually incorporated into the plasmid ***along with the gene of interest***
   - sometimes other genes to allow for selection such as LacZ are targeted for inactivation

Incorporation of Recombinant Plasmids

There is loads of detail to this, but for today a brief overview:

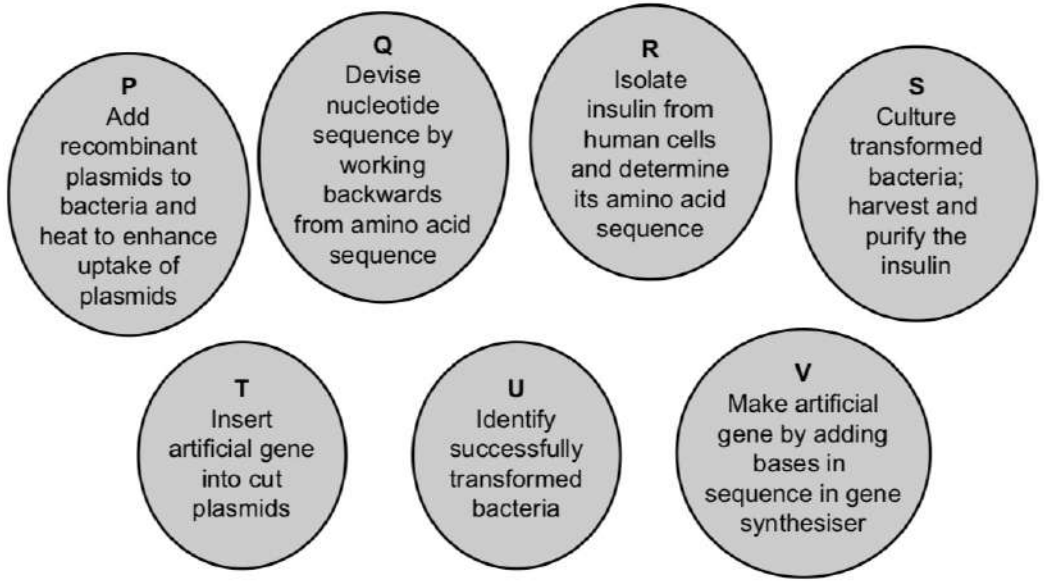
- Essentially the bacteria to be transformed is (one of two):
  - Heat shocked to destablise the membrane and allow the vector into the cell
  - Electrically shocked to create holes in the membrane to allow the vector into the cell

- The transformed bacteria is then left to grow on an agar with antibiotics to ensure the bacteria that grows has the recombinant DNA with the gene of interest
  - Remember we incorporated antibiotic resistance, if the bacteria did not take up a transformed plasmid or took up a plasmid that reformed before the genes could be incorporated will die to the antibiotic

DNA Manipulation

VCAA Question

Bacteria can be transformed with an artificial insulin gene and cultured to make insulin in commercial quantities. The steps taken to produce genetically engineered insulin are summarised below. The order of the steps has been mixed up.



Question 34

The correct sequence of steps when producing the insulin is

A. V, P, T, S, U, R, Q.

B. V, T, P, U, S, Q, R.

C. R, Q, V, T, P, U, S.

D. R, V, Q, T, P, S, U.

DNA Manipulation

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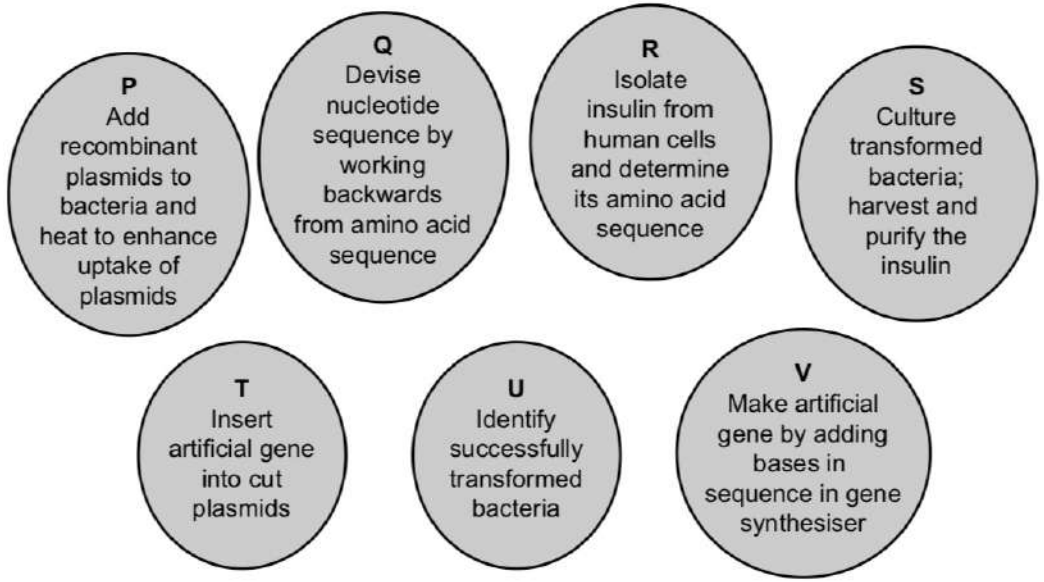

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B. V, T, P, U, S, Q, R.

C. R, Q, V, T, P, U, S.

D. R, V, Q, T, P, S, U.

Genetically Modified Organisms

- GMO: Any organism that has had its genome *artificially altered* (its genetic information/DNA has been changed in some way)
  - Can be though the addition of a gene/piece of DNA
  - Can be the modification of existing genes/DNA
  - Can be the knockout (loss of function) of a gene
- Transgenic organism: an organism that has had genetic information from *another species* inserted into its genome
  - The inserted foreign gene is called a transgene
  - Can be inserted via pronuclear microinjection or via a retrovirus

- Therefore, every transgenic organism is also a genetically modified organism, but not all genetically modified organisms are transgenic

- the use of genetically modified and transgenic organisms in agriculture to increase crop productivity and to provide resistance to disease.

DNA Manipulation

BT Cotton

This is a common example that has popped up in exams multiple times, feel free to read through it in your own time:

- Cotton plants have always been vulnerable to insects destroying their cotton buds. In 1966 BT Cotton was created, using agrobacterium as a vector, the CRY1Ac gene was inserted into the cotton plants. This gene encoded produced a protein that acted as a natural insecticide against leaf eating caterpillars.

- When looking at this example think about:
  - Ethical, social and biological pros and cons
  - How was it created?
  - GMO? Transgenic?

Ethical Considerations

Yes, you are now in an ethics class

- But in all seriousness, this has been super high yield in the past, so a small summary table.
- Importantly, it does not necessarily need to be a negative, it could be a positive or neutral

Consideration	What it should centre around
Ethical	Essentially you want to say ‘playing God’ without saying ‘playing God’
Social	Think money and power, this is all economical and political in my mind
Biological	Natural selection, artificial selection, genetic diversity, mass extinction, etc.

ATARNotes

Area of Study 2

How are biochemical pathways regulated?

ATARNotes

1. Regulation of biochemical pathways in photosynthesis and cellular respiration

Enzyme Basics

Enzyme Definitions

But firstly, enzyme basics:

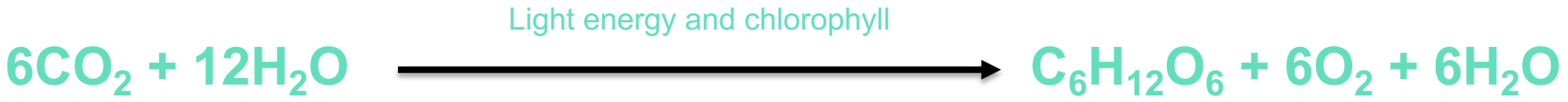
- Enzymes: biological catalysts (proteins) that lower the activation energy for a reaction thereby increasing the rate of reactions
  - They are highly specific to one substrate
- Coenzyme: small organic molecules that assist enzymes in their functioning
  - Some reactions require additional factors to occur e.g. electrons, energy
  - Pairs you need to know: NAD^+ & NADH, $NADP^+$ & NADPH, ATP & ADP + Pi
- Biochemical Pathway: a series of enzyme-mediated reactions where the product of one reaction is used as the substrate in the next

- the general structure of the biochemical pathways in photosynthesis and cellular respiration from initial reactant to final product

- the general role of enzymes and coenzymes in facilitating steps in photosynthesis and cellular respiration

Chemical Equations

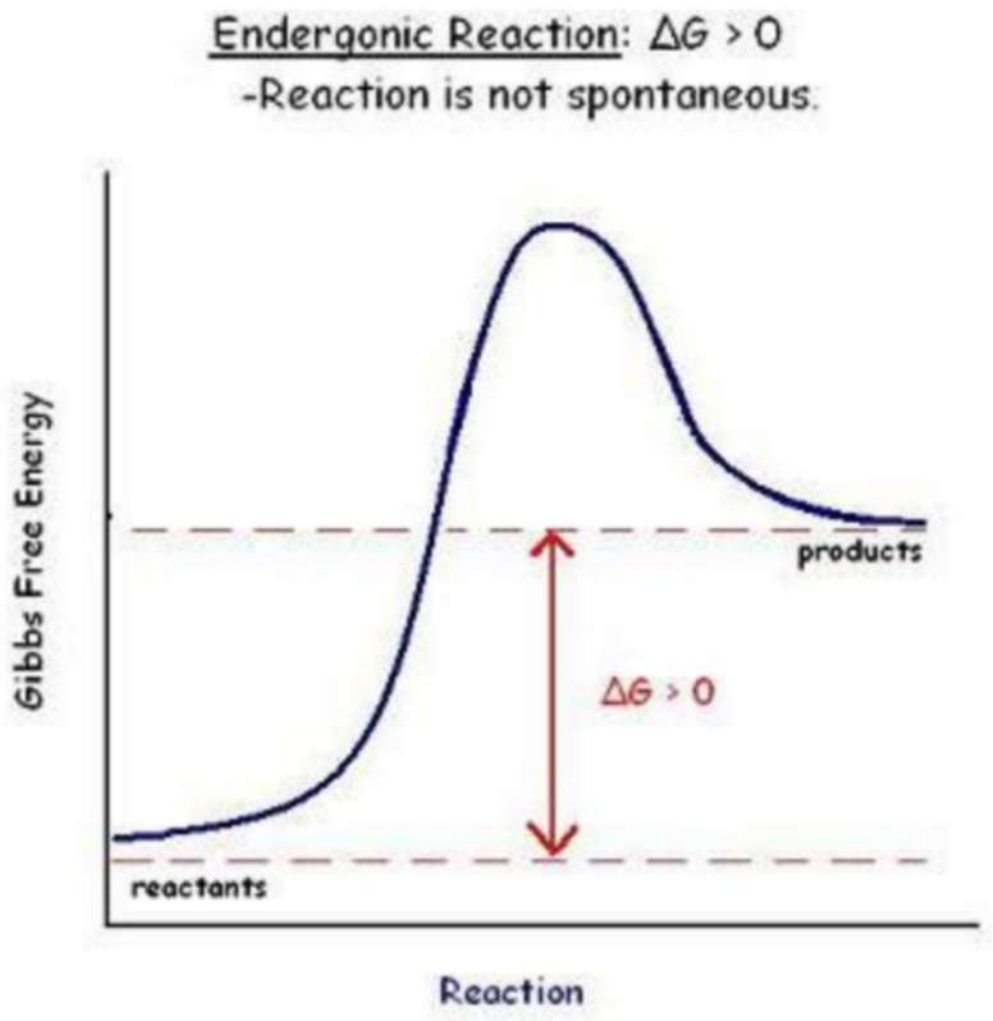
Photosynthesis:

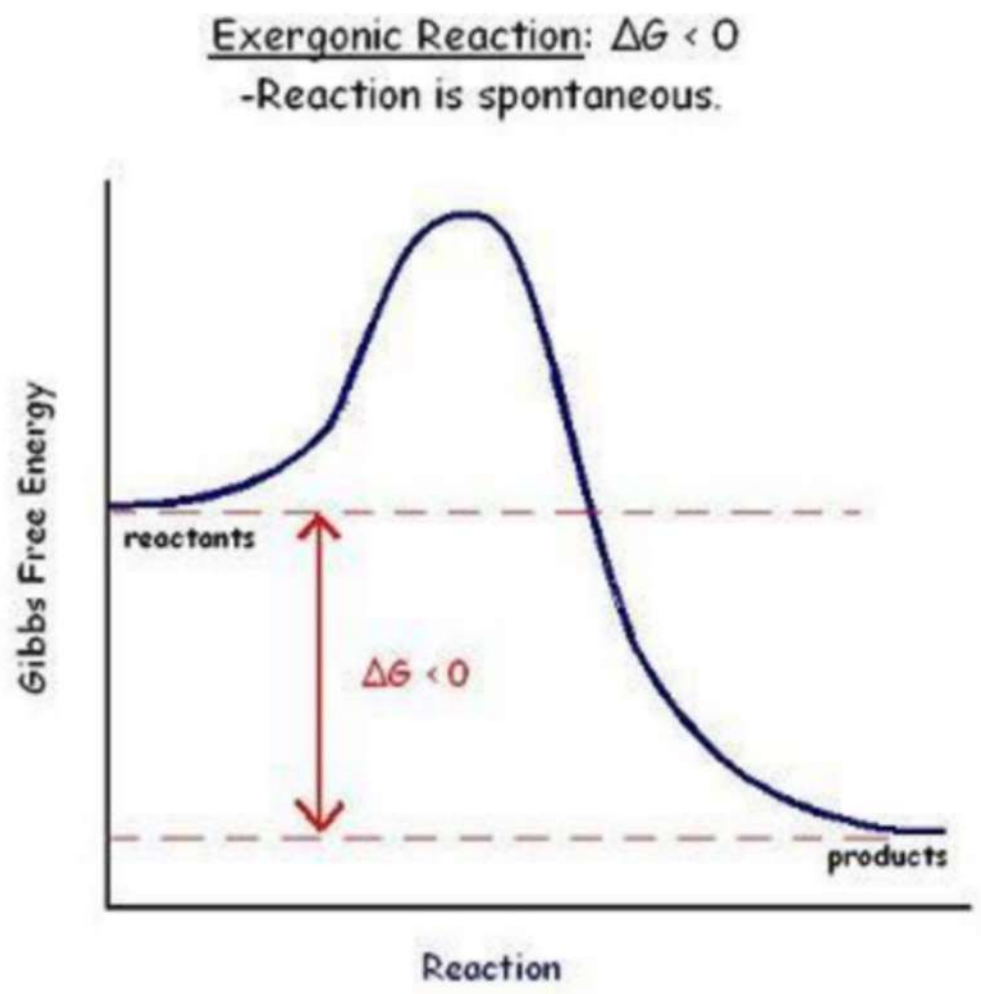


Cellular Respiration:

Enzyme Basics

Exo vs Endo

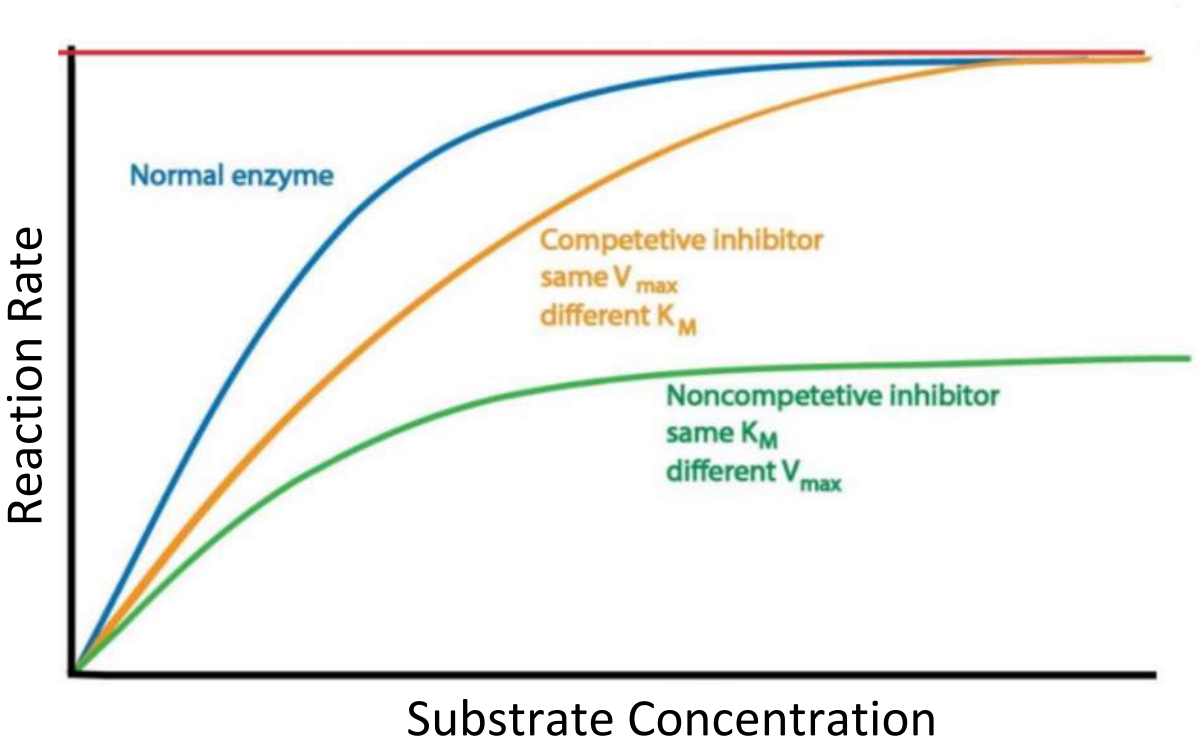




Factors Impacting Enzyme Activity

5 major factors you need to know:

- Temperature
- pH
- Substrate Concentration
- Competitive Inhibitor
- Non-competitive Inhibitor

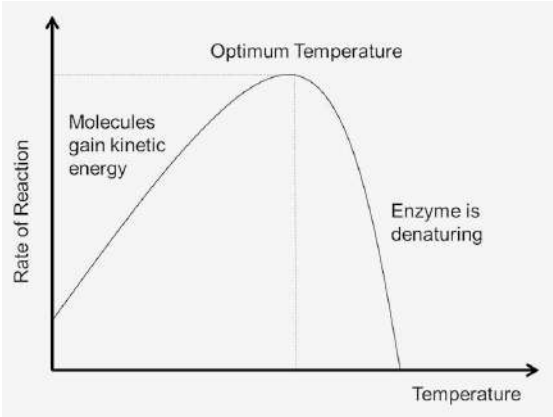


- the general factors that impact on enzyme function in relation to photosynthesis and cellular respiration: changes in temperature, pH, concentration, competitive and non-competitive enzyme inhibitors

Factors Impacting Enzyme Activity

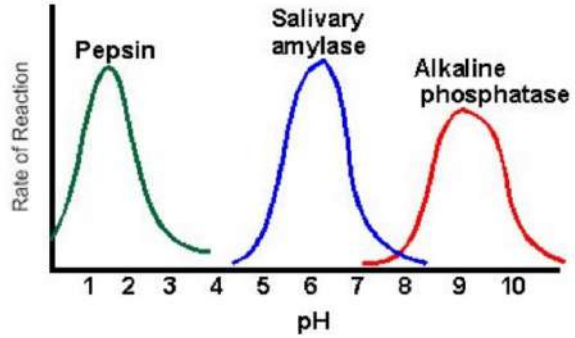
Temperature:

- Proteins denature at temperatures > optimum
- They shrink and slow (reduced kinetic)



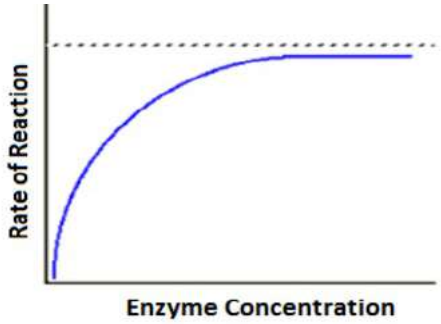
pH:

- Proteins denature both sides of optimal pH



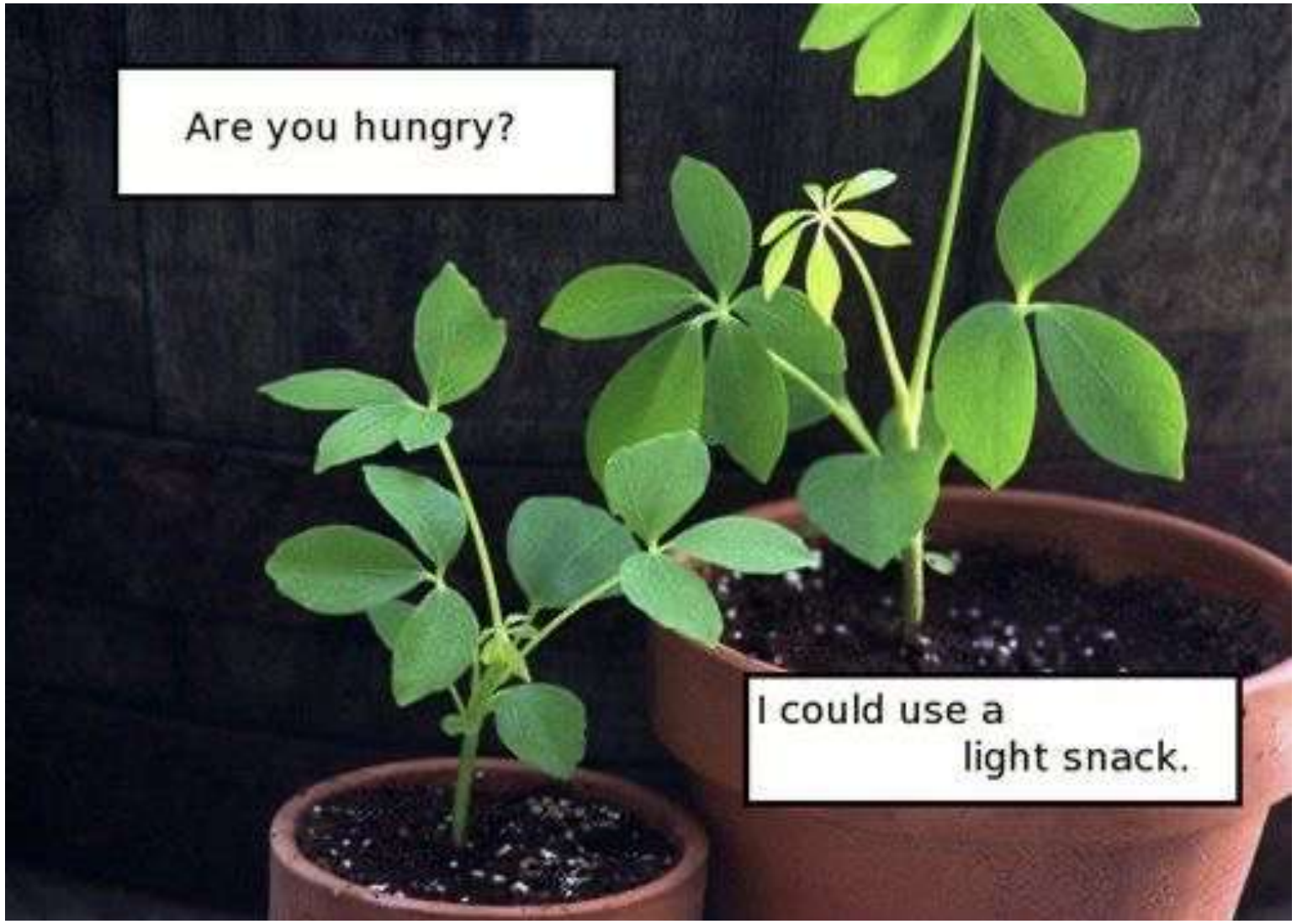
Substrate (or Enzyme) Concentrations:

- Increase to a saturation point where the rate plateaus



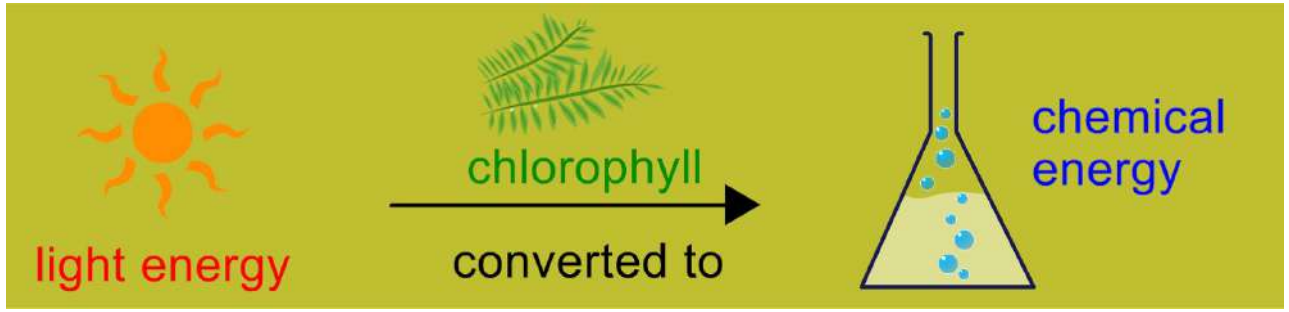
ATARNotes

2. Photosynthesis as an example of biochemical pathways


Are you hungry?
I could use a light snack.

Photosynthesis

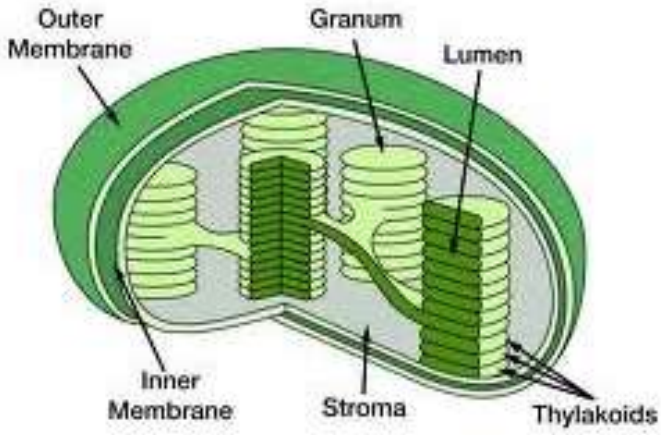
- Plants convert light energy into chemical energy by reducing carbon dioxide to glucose
- This is achieved by harnessing the sun's light to convert CO_2 into glucose which can then be used by the plant to generate ATP
- Basically, the opposite of cellular respiration



- inputs, outputs and locations of the light dependent and light independent stages of photosynthesis in C_3 plants (details of biochemical pathway mechanisms are not required)

Photosynthesis

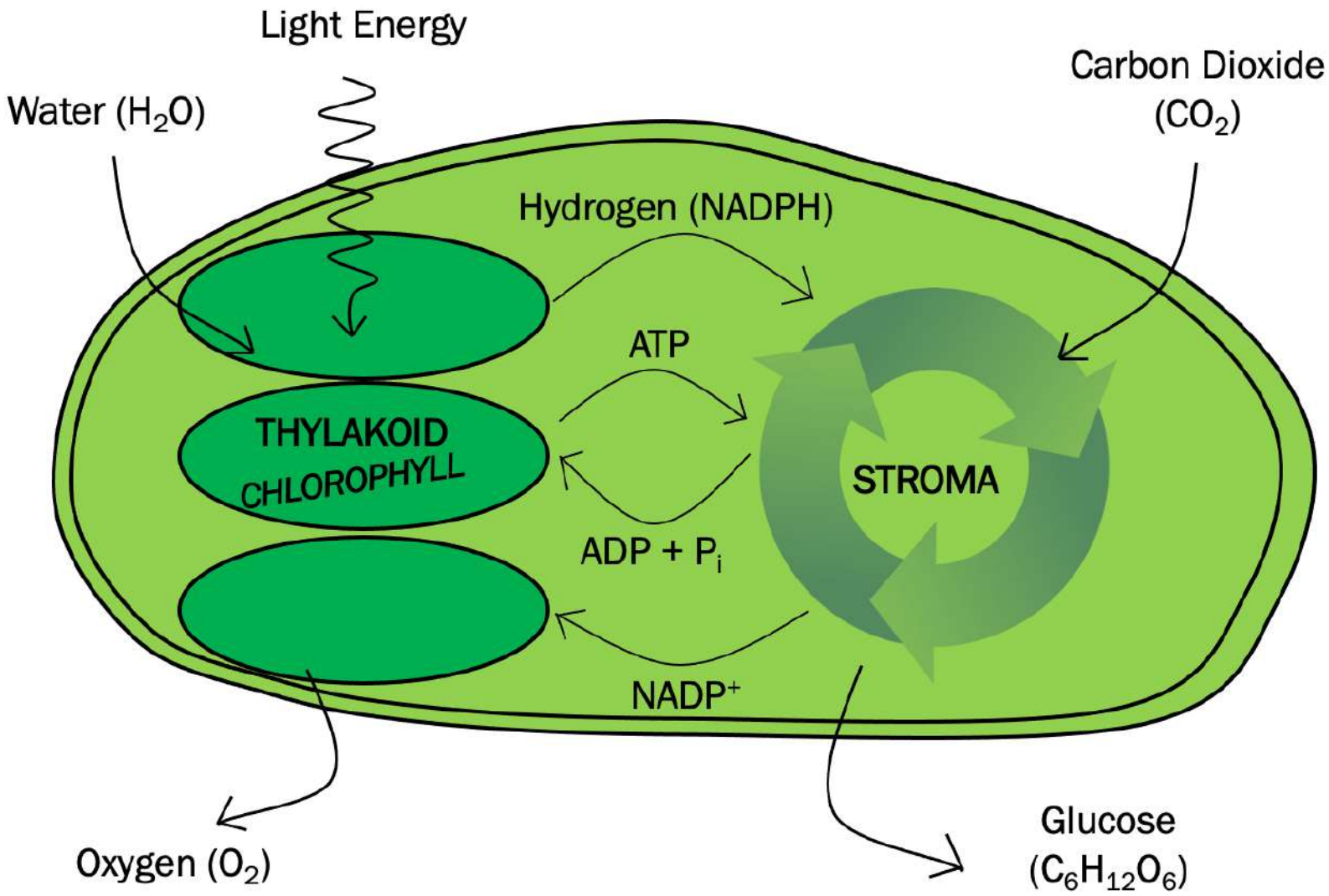
Chloroplast



- So where does photosynthesis occur?
  - At a specific organelle called the *chloroplast*
  - These are what makes plants leaves green!
- Photosynthesis is split up into two stages
  - The **grana:** are stacks of structures called thylakoids. This is the site of the light dependant stage of photosynthesis (since **chlorophyll** traps light here!)
  - The **stroma:** the site of the light independent stage
- Chloroplast are considered part of the endosymbiotic theory of organelles with the mitochondria

Photosynthesis

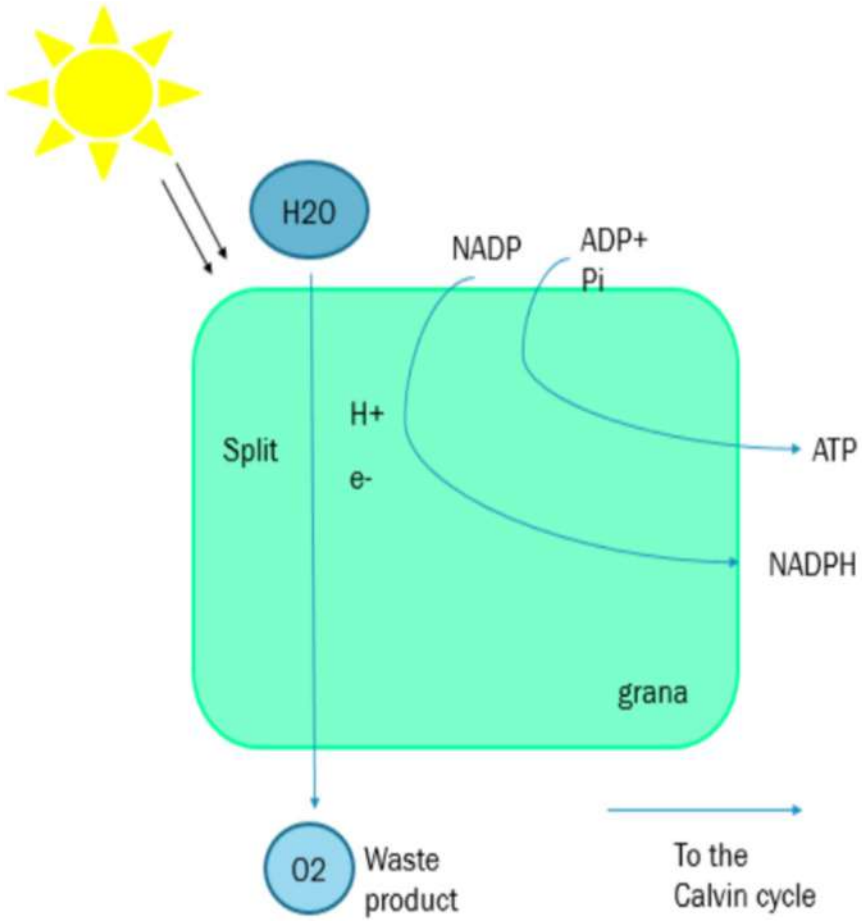
Diagram



Light Dependent Stage

Site: **GRANA**

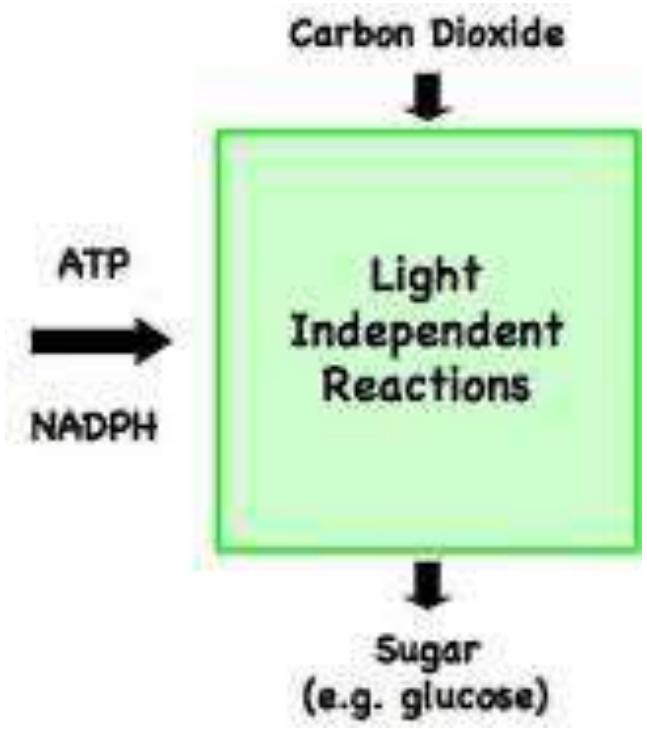
- Light energy is harnessed by the chlorophyll and used to *split water molecules* into H^+, oxygen atoms and electrons
- Oxygen atoms join to form *O_2 (oxygen gas)*, and $NADP^+$ collects H^+ and electrons forming *NADPH*
- The energy harnessed by the chlorophyll is also used to form *ATP* (in a similar manner to the electron transport chain)
- The ATP and NADPH are then used in the light independent reaction



Light Independent Stage

Site: **STROMA**

- In a series of reactions similar to the Krebs cycle, carbon dioxide is turned into glucose
- The ATP produced in the light dependent stage provides the energy to drive the reaction
- The NADPH also provides hydrogen and electrons that are needed in the reactions
- *RuBisCo* is an important enzyme in first stage of carbon fixation (the light independent reaction) stage of photosynthesis



Inputs and Outputs

Stage	Inputs	Outputs	Site
Light Dependent	• H_2O • ADP + Pi • $NADP^+$	• O_2 • NADPH • ATP	Grana
Light Independent	• ATP • NADPH • CO_2	• Glucose • ADP + Pi • $NADP^+$	Stroma

Rubisco

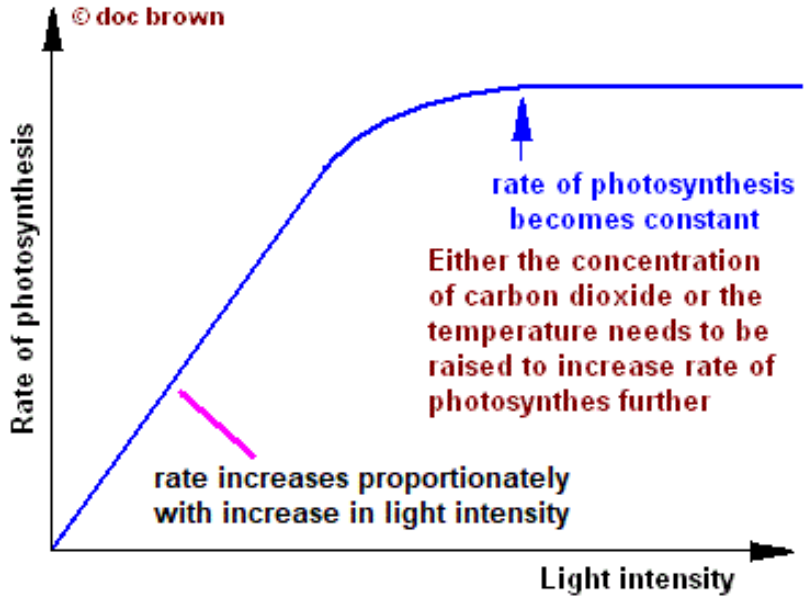
This content is super detailed, so I am only going to provide a small overview:

- Rubisco is an important enzyme in the light independent stage of photosynthesis
- Rubisco can bind to both CO_2 and O_2 due to structural similarities (chem stuff)
- Rubisco will bind to whichever has a higher concentration (which more competitive)
- Thus, if we have increased O_2 then CO_2 won't be able to bind, and the light independent stage slows and can stop
- Essentially C3, C4 and CAM plants differ in how they prevent this from happening and work in different environments etc.

- the role of Rubisco in photosynthesis, including adaptations of C_3, C_4 and CAM plants to maximise the efficiency of photosynthesis

Factors Impacting Rate

- *Light availability:*
  - More light, more photosynthesis
  - Less light, less photosynthesis
  - When fully saturated, more light will not increase rate
- *Water availability:*
  - More ~~light~~ water, more photosynthesis
  - Less ~~light~~ water, less photosynthesis
  - When fully saturated, more light will not increase rate
- *CO_2 Concentration*
  - I am not going to repeat myself again



- the factors that affect the rate of photosynthesis: light availability, water availability, temperature and carbon dioxide concentration

VCAA Question

Question 10

Plants grown in light were supplied with water containing radioactive oxygen atoms. After four hours, an analysis of the chemicals in and around the plants was undertaken.

Which one of the following would contain the radioactive oxygen atoms after four hours?

A. protein

B. glucose

C. oxygen gas

D. carbon dioxide gas

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C. oxygen gas

D. carbon dioxide gas

ATARNotes

3. Cellular Respiration as an example of biochemical pathways

Cellular Respiration

- Cellular respiration: the metabolic process whereby ATP is formed in cells from ADP + Pi using glucose as a 'fuel'
- Two forms in humans:

  - Aerobic respiration:
    - Requires oxygen
    - Produces lots of ATP
    - Occurs in the mitochondria
    - Occurs slower

  - Anaerobic respiration:
    - Doesn't use oxygen
    - Produces little ATP
    - Occurs in the cytosol
    - Occurs faster

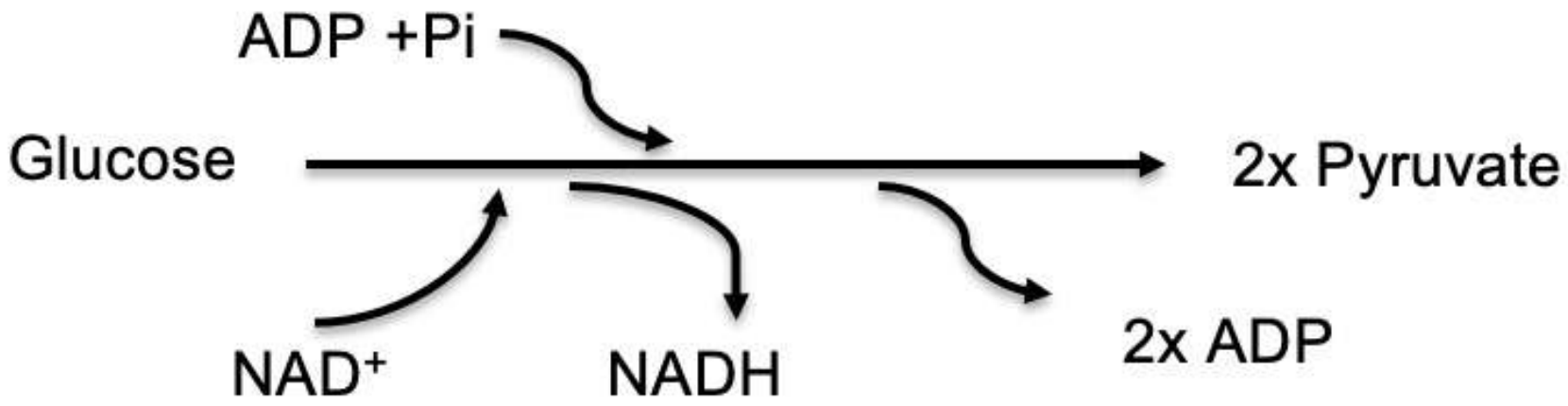
- We will start with aerobic respiration which occurs in three steps:
  - Glycolysis
  - Kreb's Cycle
  - ETC

- the main inputs, outputs and locations of glycolysis, Krebs Cycle and electron transport chain including ATP yield (details of biochemical pathway mechanisms are not required)

Glycolysis

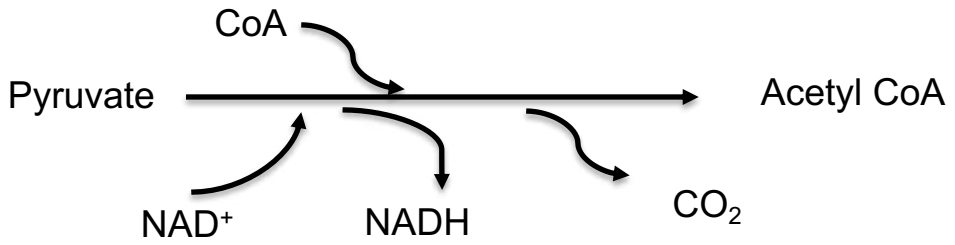
Occurs in the cytosol of cells and is essentially anaerobic as it does not require O_2

- Simple process, one 6 carbon glucose enters, and two 3 carbon pyruvates exit
- 2x ADP is yielded as well as some NADH



Now we move to the inner mitochondrial matrix:

- Step 1: ***Each*** **pyruvate (3C)** is converted to **acetyl CoA** (2C) and **1 CO_2,** the loss of electrons reduces **NAD^+** to **NADH**
- (Known as the link reaction)



- Step 2: The acetyl CoA enters the Krebs cycle in the mitochondrial matrix and with <u>each</u> 'turn' of the cycle 1 Acetyl CoA gives rise to 2 CO_2 molecules, 1 ATP, 3 NADH and 1 $FADH_2$

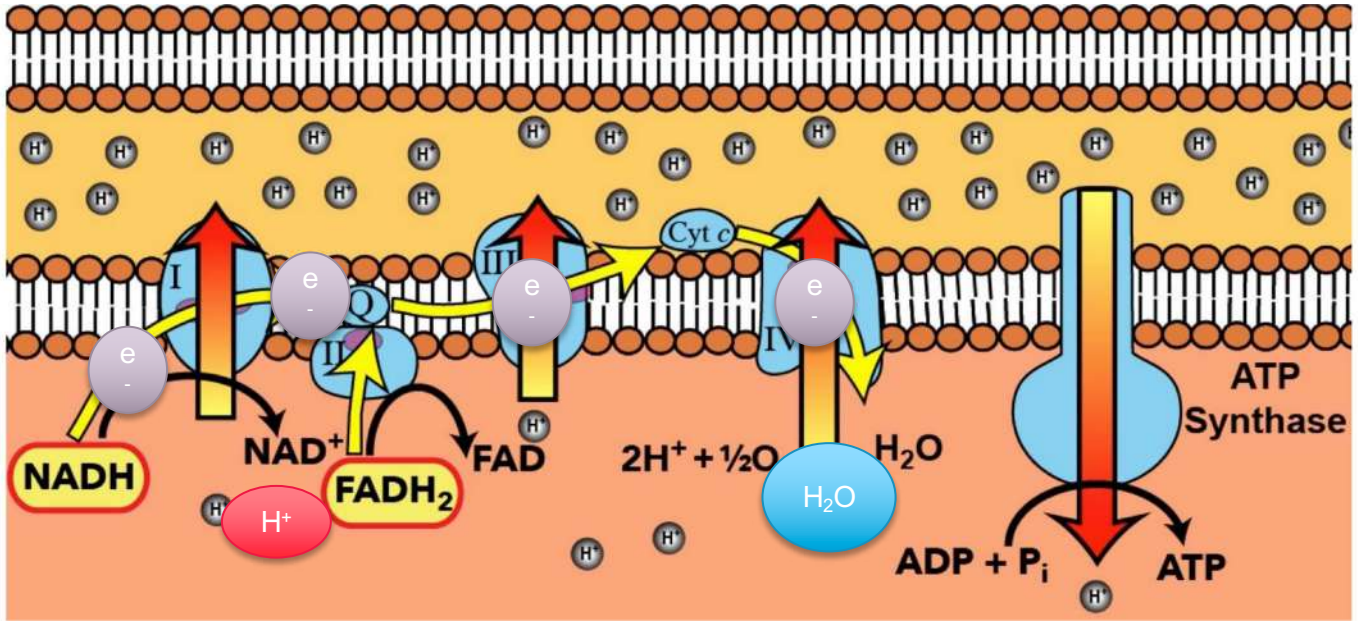
<u>TWO TURNS PER GLUCOSE</u>

Electron Transport Chain

We finally move to the Cristea of the Mitochondria:

- The ETC is SUPER confusing
- But I have animated this for simplicity
- BUT if you are still confused after this that is ok, it will take a couple of explanations to get your head around it

CRISTAE (folded inner membrane of mitochondrion)



Cellular Respiration

Inputs and Outputs

	GLYCOLYSIS	KREBS CYCLE	ELECTRON TRANSPORT CHAIN	AEROBIC RESPIRATION OVERALL	ANAEROBIC RESPIRATION OVERALL
INPUTS	• *glucose* • *ADP + P_i* • *NAD^+*	• *Acetyl CoA* • *NAD^+* • *FAD* • *ADP + P_i*	• *NADH* • *$FADH_2$* • *O_2* • *ADP + P_i*	• *glucose* • *6 O_2* • *30 or 32 ADP + P_i*	• *pyruvate* • *NADH* • *2 ADP + P_i*
OUTPUTS (per glucose)	• *pyruvate* • *2 ATP* • *NADH*	• *2 ATP* • *4 CO_2* • *6 NADH* • *2 $FADH_2$*	• *26 or 28 ATP* • *H_2O* • *NAD^+* • *FAD*	• *30 or 32 ATP* • *6 H_2O* • *6 CO_2*	• *2 lactate (animals)* • *2 ethanol + 2 CO_2 (yeasts)* • *2 ATP*
LOCATION	• *cytosol*	• *mitochondrial matrix*	• *mitochondrial cristae*	• *cytosol + mitochondria*	• *cytosol*

Factors Impacting Rate

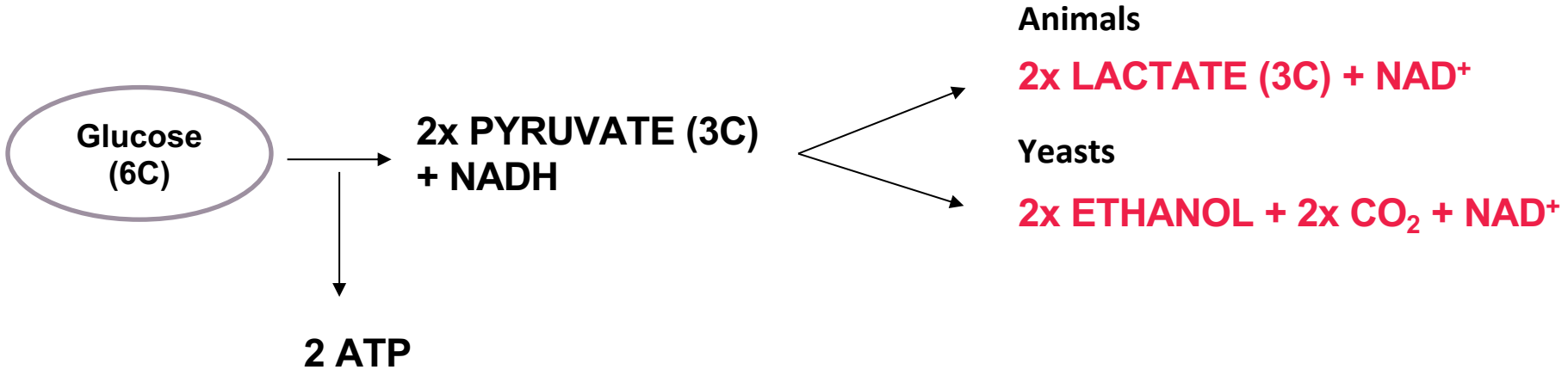
- Literally, the exact same concept as the photosynthesis impacting factors.
- Except temp…

- the factors that affect the rate of cellular respiration: temperature, glucose availability and oxygen concentration

Anaerobic Respiration

Anaerobic respiration: metabolic pathway that is followed in the absence of oxygen (or the absence of mitochondria eg// in RBCs)

- Occurs in the cytosol



- Essentially this stage is just glycolysis, then the cell processing the products
- You will 100% do a practical with yeast and measure CO_2 / Ethanol

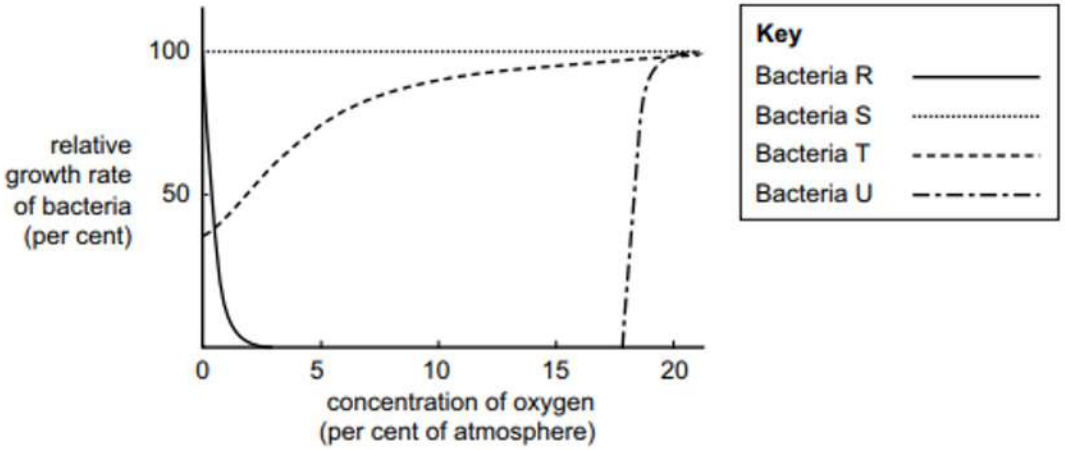
- the location, inputs and the difference in outputs of anaerobic fermentation in animals and yeasts

Cellular Respiration

VCAA Question

Question 5

The graph below shows the growth rate of different types of bacteria when the bacteria are exposed to varying concentrations of atmospheric oxygen.



Based on your knowledge and the information in the graph, which one of the following statements is true?

A. Bacteria R are unable to carry out anaerobic respiration.

B. Bacteria U are poisoned by a high concentration of oxygen.

C. Bacteria S are able to carry out both aerobic and anaerobic respiration.

D. Bacteria T are unable to carry out both aerobic and anaerobic respiration.

Cellular Respiration

VCAA Question

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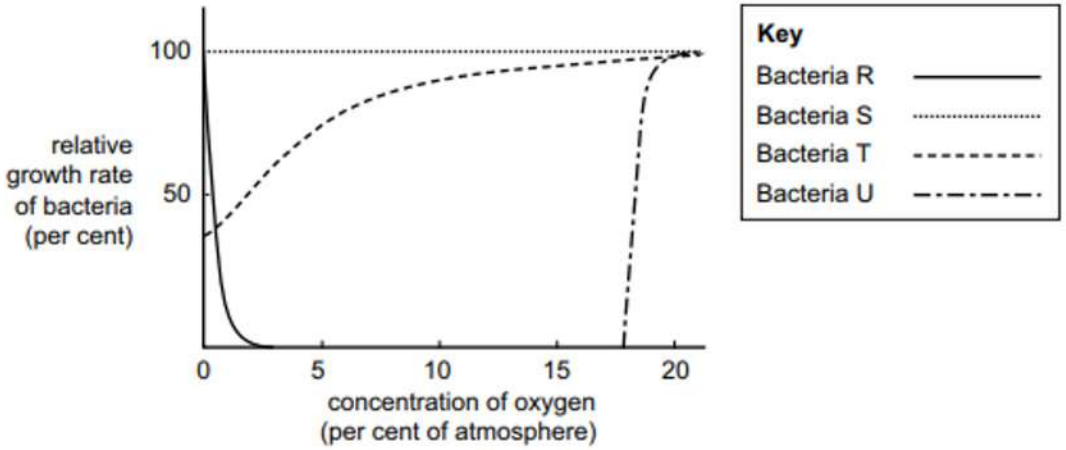

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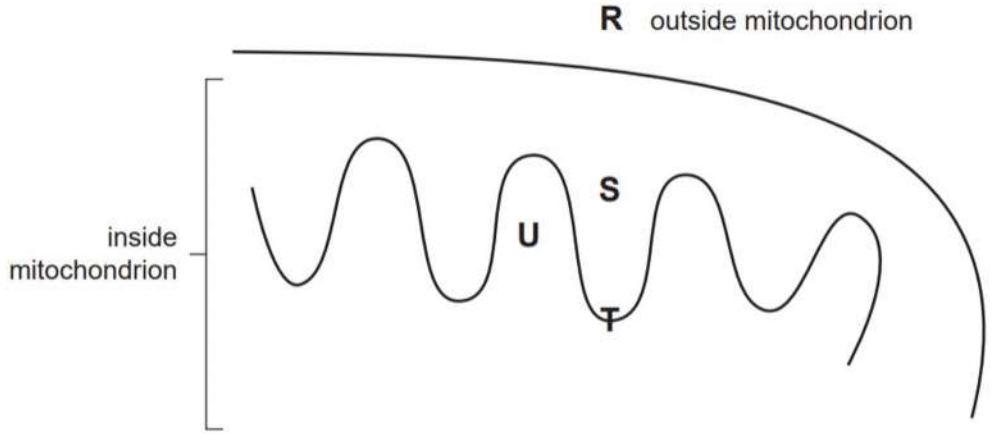
Cellular Respiration

VCAA Question

Question 8

The diagram below shows a section through a part of a mitochondrion.



The sites of the pathways in aerobic respiration are

A. R – glycolysis, S – Krebs cycle, T – electron transport chain.

B. U – glycolysis, T – Krebs cycle, R – electron transport chain.

C. R – glycolysis, U – Krebs cycle, T – electron transport chain.

D. T – glycolysis, R – Krebs cycle, S – electron transport chain.

Cellular Respiration

VCAA Question

Question 8

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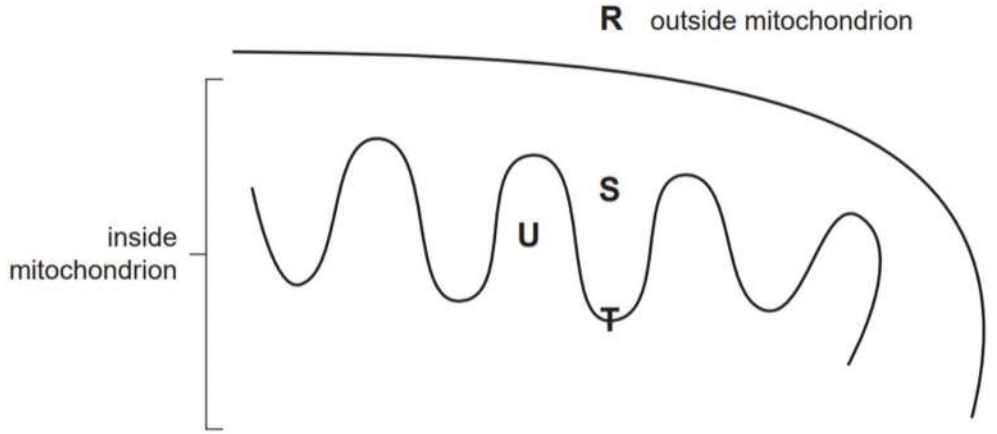

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C. R – glycolysis, U – Krebs cycle, T – electron transport chain.

D. T – glycolysis, R – Krebs cycle, S – electron transport chain.

ATARNotes

QUESTIONS?

ATARNotes

GOOD LUCK <3